United States
Department of
Agriculture

Forest Service

Intermountain
Forest and Range
Experiment Station
Ogden, UT 84401

Research Paper
INT-315

July 1983

LLAFFS – A Lightning-Locating and Fire-Forecasting System

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RESEARCH SUMMARY

This publication contains programs and documentation to implement an algorithm for calculating lightning fire probability. This calculation is based on a model originally developed for the National Fire-Danger Rating System. The model algorithm estimates the probability that a lightning discharge from cloud to ground will ignite a fire in fuels at the ground terminus of the lightning. Probability is estimated using variables that are measures of the fuel state and type, rain, and lightning. Details of the model can be found in Fuquay and others (1979), Latham (1979), and Fuquay (1980).

The lightning-locating and fire-forecasting (LLAFFS) system is designed to combine ignition probability with real-time lightning occurrence, and to transmit the results to the land manager. The lightning occurrence is assumed to be given by a Lightning Location and Protection, Inc., Position Analyzer in the form of a time, latitude, and longitude estimate for each lightning event in the area covered by the analyzer. The system programs use weather variables and the state of the fuels for the place the lightning hit ground; the algorithm is used to calculate the probability that the discharge started a fire. Probabilities are added with varying time scales to provide running totals that are recorded by the programs.

The land manager needs to know the location of probable fires. The transmission of this information must be cost-effective and the output convenient to use. We have developed a method for storing and transmitting lightning fire probability data using a simple printing terminal as a user interface device. The area occupied by a character on a printed page of text, called a pixel, is made to correspond to a geographical area on a map. An array of printed characters can thus be used with transparent overlays. The overlays "store" permanent information such as lookouts, roads, political boundaries, geographic features, equipment centers, areas of responsibility, or other desired data.

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A Lightning-Locating and Fire-Forecasting System

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1.0 INTRODUCTION

This publication contains programs and documentation to implement an algorithm for calculating lightning fire probability, developed at the Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station. The calculation of lightning fire probability is based on a model originally developed for the National Fire-Danger Rating System. The model algorithm estimates the probability that a lightning discharge from cloud to ground will ignite a fire in fuels at the ground terminus of the lightning. Probability is estimated using variables that are measures of the fuel state and type, rain, and lightning. Details of the model can be found in Fuquay and others (1979), Latham (1979), and Fuquay (1980).

The lightning-locating and fire-forecasting (LLAFFS) system (figs. 1 and 2) is designed to combine ignition probability with real-time lightning occurrence, and to transmit the results to the land manager. The lightning occurrence is assumed to be given by a Lightning Location and Protection, Inc. (LLP) Position Analyzer in the form of a time, latitude, and longitude estimate for each lightning event in the area covered by the analyzer. The system programs use weather variables and the state of the fuels for the place the lightning hit ground; the algorithm is used to calculate the probability that the discharge started a fire. Probabilities are added with varying time scales to provide running totals that are recorded by the programs.

The land manager needs to know the location of probable fires. The transmission of this information must be cost-effective and the output convenient to use. We have developed a method for storing and transmitting lightning fire probability data using a simple printing terminal as a user interface device. The key to the method is that the area occupied by a character on a printed page of text, called a pixel, can be made to correspond to a geographical area on a map. An array of printed characters can thus be used with transparent overlays. The overlays "store" permanent information such as lookouts, roads, political boundaries, geographic features, equipment centers, areas of responsibility, or other desired data.

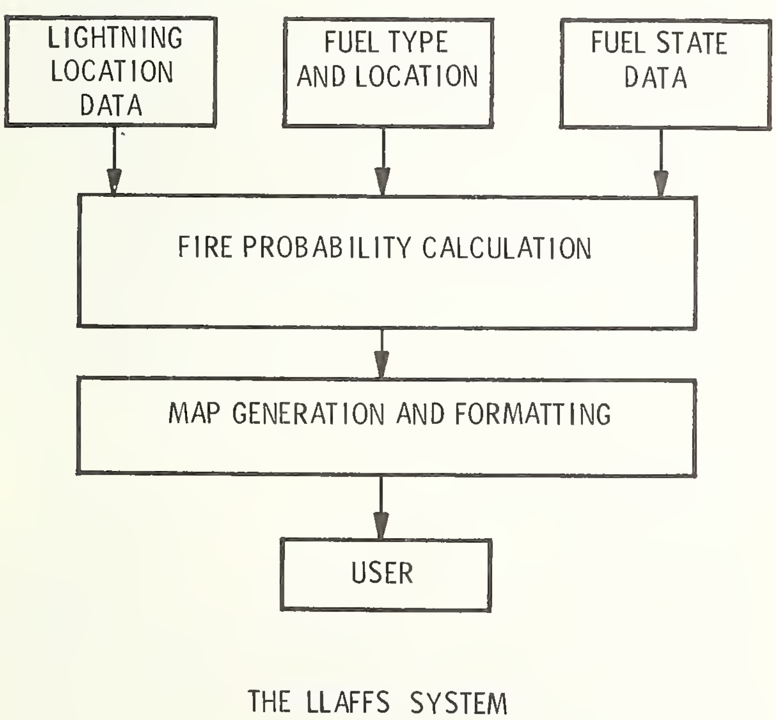


Figure 1.—Overall functional diagram of the LLAFFS system.

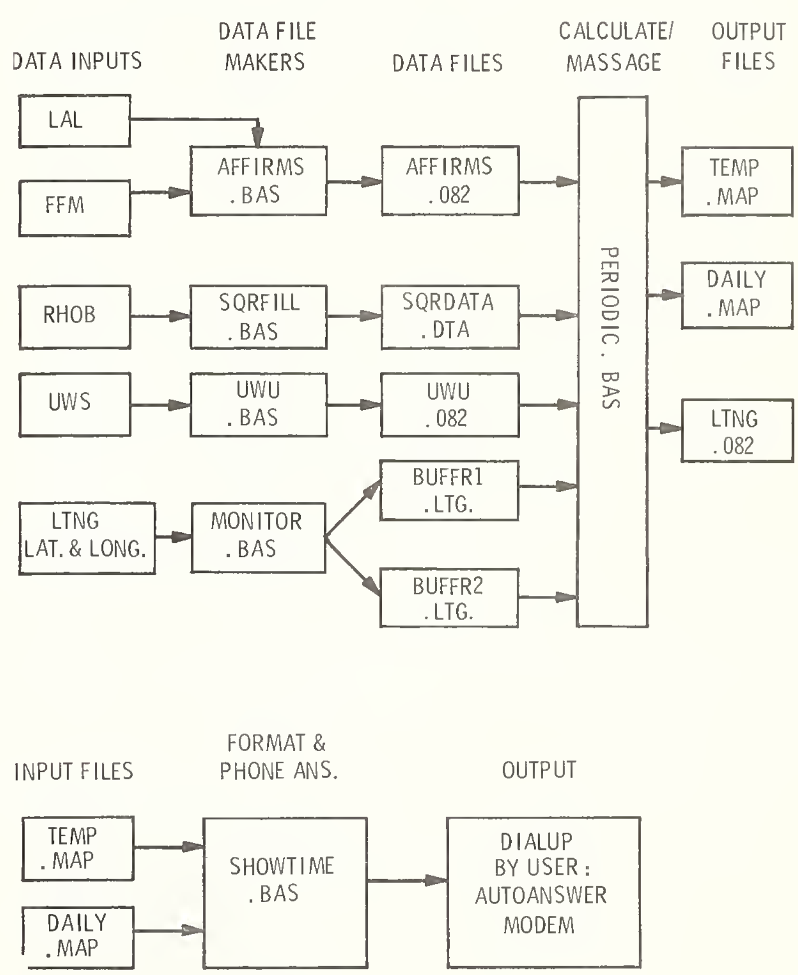


Figure 2.—Data flow, programs, and files of the LLAFFS system.

Figure 2 presents a data flow block diagram of LLAFFS. In use, the system runs as follows:

- The data file maker programs are periodically applied by the LLAFFS (not the field user) operator to provide current environmental data,
- which, along with real-time lightning location data, are turned into data files to be read by the probability calculation program,
- whose output files become input files to the "telephone operator,"
- which a field user calls on his/her terminal for the formatted fire probability data.

Our implementation of the LLAFFS system was done on a minicomputer. The programs, written in BASIC, were structured to match its capability for handling several programs and several users at the same time. If such a machine is not available, the programs may be adapted for use with a smaller machine, such as some of the commonly available microcomputers.

1.1 COMPUTING MACHINERY REQUIRED

The minimum machinery necessary to run LLAFFS would be a microcomputer, printer, and modem(s). This equipment will enable acquisition of AFFIRMS data, control of an LLP Position Analyzer (or reception of data from one), and output of printed data for local use with overlays Overlays also work very well on the front of CRT displays; even the printer might be unnecessary for some applications (although recommended). More than one modem will be required for dial-up access. Interrupt-driven software is necessary if a multitasking/multiuser operating system is not available.

The following sections of this package contain technical information for implementation. For an overview, the reader may skip to section 2.5.1.

2.0 INFORMATION FLOW: SYSTEM BLOCK DIAGRAM

Figure 2 presents the overall data flow for the LLAFFS system. The data inputs consist of Lightning Activity Level (LAL), fine fuel moisture (FFM), fine fuel bulk density (RHOB), upper windspeed (UWS), and lightning locations (in latitude and longitude) from the position analyzer. Only the lightning locations are on-line (real-time) inputs; the others are entered manually at the host computer. All information between system programs is passed through files.

2.0.1 Data Inputs—Geographical Assignment

The implementation of LLAFFS should begin by choosing a suitable overlay map scale, pixel size, and map limits (fig. 3). The map limits and pixel size are used by the computer programs only in PERIODIC.BAS (see 2.4.1 and flowchart, appendix C). The program SQRFILL.BAS (see 2.2.1) uses index numbers only and has no explicit geography. A guide map, or the overlay master map, must be used to decide the fuel types and AFFIRMS reporting stations to be used.

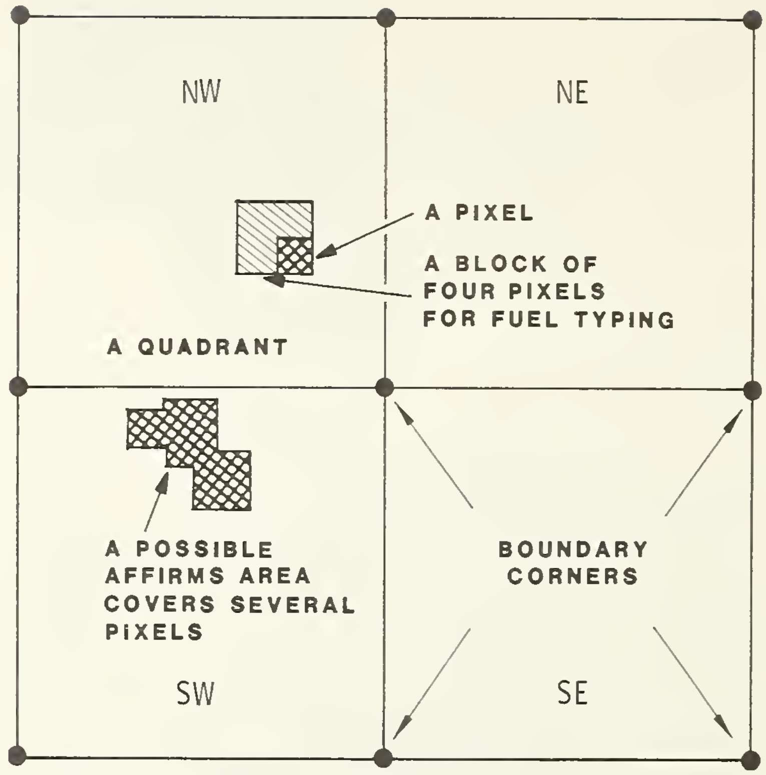


Figure 3.—LLAFFS system geometry/geography.

2.1 DATA INPUTS DESCRIPTION

The ignition model requires Lightning Activity Level as one of its inputs. Fuquay (1980) explains the meaning of this number, and provides simple methods of estimation. Although the LAL specifies a number of lightning strokes, the actual number is used in computation. Another variable required is the steering windspeed for storms in the area of interest. The Weather Service standard 500-millibar windspeed can be used with little error. The fuel bulk density can be estimated as shown in Fuquay and others (1979). This variable is important in the calculation; be sure it is as accurate as possible. If none of the fuel models described in table 5 of the above paper fits exactly, however, the closest approximation will have to do. In general, RHOB for long-needled conifers will be 4 pounds per cubic foot, short-needled conifers 6 to 8, grass 2, and broadleaf species 4. The remaining input variable, fine fuel moisture, is available from AFFIRMS or is calculated according to the National Fire-Danger Rating System. If a different rating system is in use, then some means of conversion to the NFDRS 1-hour timelag moisture content must be applied.

2.2 DATA FILE MAKERS

The data file maker programs are used to set up the LLAFFS system and update some of its inputs. We will discuss the programs in the order in which they are applied in use. The flowcharts and program printouts can be found in appendix C. **Note that all LLAFFS files except SQRDATA.DTA must be externally created at the initial implementation of the system.**

2.2.1 SQRFILL.BAS

This program creates a file SQRDATA.DTA, which contains a bulk density (RHOB) and AFFIRMS station code number for each of the pixels. The pixels are grouped into blocks of four (fig. 3). Each block of four has an AFFIRMS station assigned to it. Some stations will be assigned to more than one block. The stations are chosen by the user to be most representative for Lightning Activity Level and fine fuel moisture data. This program will probably be used very seldom, because the bulk densities for the pixels, as well as AFFIRMS stations, will not change appreciably over a season and probably very little from season to season. For this reason, SQRFILL is not a very "user friendly" program. Details of the file format are in section 2.3.2.

2.2.2 AFFIRMS.BAS

This is a program which prompts the user to enter LAL and FFM values for each selected AFFIRMS reporting station in the area covered by the maps. The number of stations will vary by the application (fig. 3). Our application used 73 stations. Several pixels on a map may use FFM and LAL information from the same AFFIRMS station (2.2.1). The file AFFIRMS.082 is updated and passed to PERIODIC.BAS. PERIODIC.BAS, by knowing a pixel's AFFIRMS station code number, assigns the appropriate values of FFM and LAL to a pixel. We wished to keep a running record of the AFFIRMS data. Because of this, the file AFFIRMS.082 can be extended each time AFFIRMS.BAS is run. It is unlikely that this will be desired in most applications, so we have provided for rewrite or append functions in this program. If data files are not desired, answer "R" (rewrite) at the "Rewrite (R) or Append (A)" prompt. Choice of rewrite mode will wipe out all data that may have been filed from previous append mode operations, so take care here.

2.2.3 UWU.BAS

UWU.BAS creates a file called UWU.082, which is used when PERIODIC.BAS updates the upper windspeed variable. In general, the upper windspeed value will be the same for most of the pixels. The version of the program given here passes, to UWU.082, the current values of the upper windspeed at three stations and the date and time. The actual calculation of the UWS values for each pixel is done in PERIODIC.BAS. As with AFFIRMS.BAS, we have an append or rewrite choice. The rewrite choice will wipe out any data left from previous append mode operation. Take care when answering "Append (A) or Rewrite (R)" if data files are to be kept.

2.2.4 MONITOR.BAS (SUPERMON.BAS)

The lightning data from an LLP Position Analyzer is received and filed by this program. In our application, MONITOR is an interactive task running on a multitasking machine. There is more than one input data stream for lightning data in this version of the monitor program, as well as some communication with other computers. Our program is included in the package for completeness and as an example for generating the buffer files in the correct format for PERIODIC.

The lightning data go into one of two buffer files, as input for PERIODIC.BAS. These files, BUFFR1.LTG and BUFFR2.LTG (2.3.4), are necessary to prevent loss of data during the running of PERIODIC. If the machine running these programs is not multitasking, then a different MONITOR will be necessary to prevent lost lightning data. One possibility is an interactive program to take advantage of the core storage in the Position Analyzer. Other schemes depend on the available hardware.

2.3 DATA FILE DESCRIPTIONS

As we have seen, there are five intermediate data files within the LLAFFS system. These contain the updated values of the input variables. The files are inputs to the probability predictor and output file maker program, PERIODIC.BAS. Depending on the type of computer being used as the host, the data files may be updated interactively at any time, except when PERIODIC is reading them (2.2.4, 1.1). We will describe the file contents in the order shown in figure 2.

2.3.1 SQRDATA.DTA

This file, created within SQRFILL.BAS, contains encoded bulk density and AFFIRMS station code numbers for each block of a 24 by 24 array, hence its length of 576. The number of blocks depends on the implementation. Each record contains a number that tells PERIODIC.BAS which AFFIRMS data station and RHOB index are to be used. Each square is representative of a block of four pixels in the final map. Both pieces of information are combined into a single number in the file. The form of this number is (station number*100) + RHOB index.

2.3.2 AFFIRMS.082

The first record in this file is the record number of the last record written. The subsequent data items are packed into nine records; they contain the latest data produced by AFFIRMS.BAS. The first value in the nine records is the time in minutes from January 1 of the year that the AFFIRMS data was measured. Next are values for FFM and LAL, one for each reporting weather station. These values are coded (multiplexed) by AFFIRMS.BAS into a single number for each station for efficient packing. The form of this number is (LAL*100) + FFM. The number of AFFIRMS stations will vary according to the application; we used 73. It is important to note that the number of variables is not the same as the number of records in the file; there are nine records, one for each BASIC "outfile" statement. If the rewrite mode is chosen, the file is wiped clean; any data that has been entered in append mode will be lost.

2.3.3 UWU.082

As with AFFIRMS.082, this file, created externally at implementation, can either be appended to or rewritten. The number of records depends on whether the append mode or the overwrite mode is used in UWU.BAS. The first record contains the record number of the beginning of the latest data written. Then follows a record with the calculated local time in minutes since the beginning of the year that

the observations were taken (as in AFFIRMS.082) and three wind speeds. A different time code scheme can be used. The appended file will grow continuously. If the rewrite mode is chosen at any time, all data from an appended file will be lost.

2.3.4 BUFFR1.LTG and BUFFR2.LTG

These are two identical files containing lightning data to be read by PERIODIC. They are identical in format, and random in length. They must be initially created at implementation of LLAFFS. They are alternately read and flushed so that the maximum size of either would be in the neighborhood of 2,000 78-byte records.

2.4.1 PERIODIC.BAS—The Main Program

PERIODIC.BAS (fig. 4) is the workhorse for LLAFFS. This program, running as a background task, performs the following functions:

(1) takes in the values of the input variables (RHOB, FFM, LAL, UWS) from the AFFIRMS.082, SQRDATA.082, and UWU.082,

(2) takes in lightning data from BUFFR1.LTG and BUFFR2.LTG,

(3) gets the appropriate values of variables and lightning for each pixel from the files,

(4) calculates the probability of ignition per discharge in each pixel,

(5) updates the half-hour (or other selected interval) maps,

(6) updates the cumulative (daily) maps, and

(7) generates archival files.

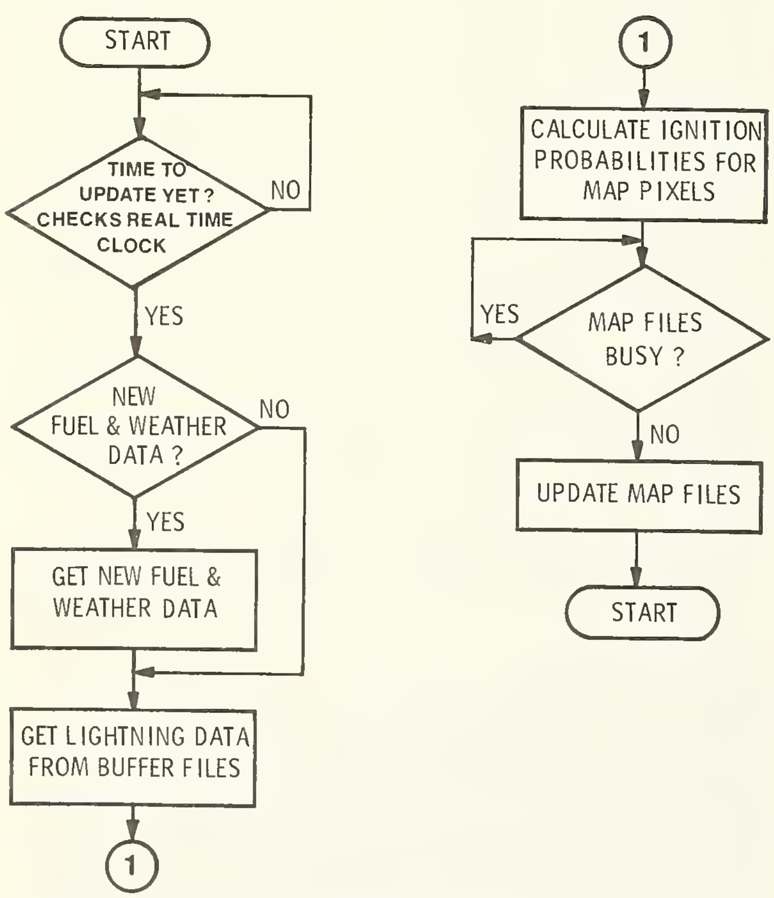


Figure 4.—PERIODIC.BAS functional diagram.

Input files to PERIODIC are discussed in section 2.3. The output files (see 2.4.2) are TEMP.MAP, DAILY.MAP, and LTNG.082. PERIODIC also uses four files for temporary storage as it runs. These are BUFR.MAP, LTOTL.DTA, and HALFHR.CNT. The temporary files are created when the system is implemented. The first of these temporary files is used in merging the last interval's data with the DAILY.MAP file. The second, LTOTL.DTA, contains total lightning strikes for pixel groups. The third, HALFHR.CNT, contains the lightning counts by pixel for the last half-hour time period. This file is put in BUFR.MAP and a new HALFHR.CNT is calculated. The fourth file contains communications between PERIODIC and MONITOR to tell MONITOR which lightning location buffer file (see 2.3.4) to use.

The host computer must have a real-time clock so that PERIODIC will know what time it is. The update interval and the beginning-time of the 24-hour DAILY.MAP file are set in PERIODIC. For optimum machine use, PERIODIC should be called from an interrupt routine in the operating system, instead of having a loop as our version does. Indeed, if the system is to be installed on a non-multitasking machine, MONITOR must be the control program, running all the time, and contain a call to PERIODIC. The two programs can call each other using a chain command because all information is passed in files. A single-user machine may lose some data during the PERIODIC running time, unless interrupt-driven software has been devised.

2.4.2 PERIODIC.BAS Output Files

PERIODIC.BAS (figs. 2 and 4) uses three output files, TEMP.MAP, DAILY.MAP, and LTNG.082. The files are created externally when LLAFFS is implemented. The last is archival and will not be discussed. TEMP.MAP contains the latest half-hour counts and DAILY.MAP the cumulative count for the current day. The beginning of the day is set in PERIODIC.

The structure of TEMP and DAILY are shown in figure 5. Each record after the first five contains three variables. The first is the row and column of the pixel to which the data belong. The second variable is the number of lightning discharges that the location equipment claims has struck the ground in the area represented by the pixel. The third is the probability per discharge of an ignition in the area represented by the pixel. The product of probability per discharge and the number of discharges, although not exact, is used for the probability that an ignition will occur within the ground area represented by the pixel.

A listing and flowchart for PERIODIC are in appendix C.

2.5 SHOWTIME.BAS, The Output Program

SHOWTIME (figs. 3 and 6) is designed to read the output files DAILY.MAP and TEMP.MAP and format them into printer-compatible form for output to the user. A listing and detailed flowchart of SHOWTIME are included in appendix C.

The program has been optimized to reduce printing time to a minimum. Rows in the output map having no data are output as a carriage return-linefeed pair. The row is truncated at the last pixel having data in it. Maps with no data are not printed, and a "no data" statement is output in place of the map.

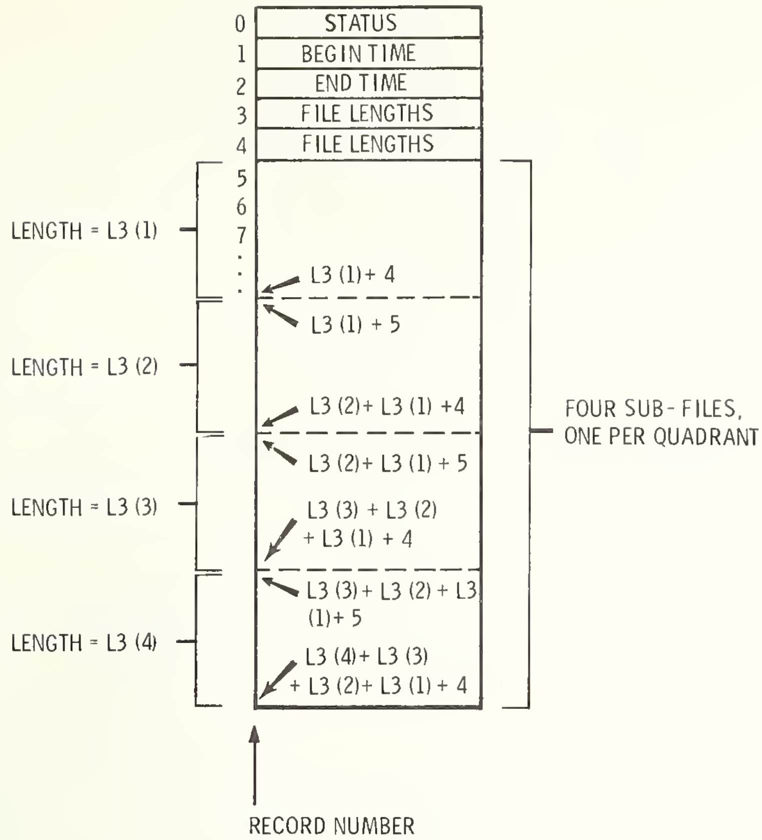


Figure 5.—DAILY.MAP and TEMP.MAP file structure.

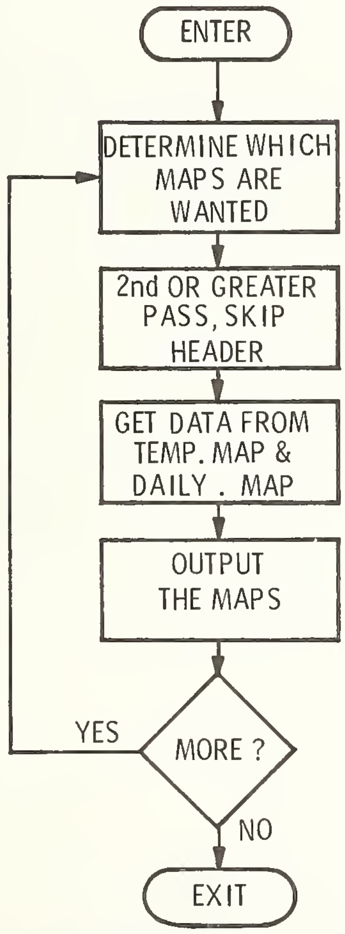


Figure 6.—SHOWTIME.BAS functional diagram.

2.5.1 OUTPUT FORMAT

Examples of SHOWTIME.BAS output are shown in figures 7 and 8. In these examples, each pixel represents an area on the ground of about 3 miles by 3 miles. There is, of course, nothing sacred about this size—it can be changed by altering the programs (see 2.0.1) and overlay maps to suit the occasion.

The lightning density map (fig. 7) is straightforward. An "X" is placed as an index mark in the upper and lower left corners of the printout. The index mark is keyed to the overlay. Each pixel contains a number. This is the number of strikes the location system says have hit within the corresponding overlay area on the ground. Zeroes are suppressed, and more than nine strikes in a pixel is represented by an "*". The time period is specified in the text accompanying the printed map.

The fire probability map (fig. 8) is almost as simple. The numbers do not indicate the number of fires expected in each pixel. The numbers are codes representing the probability of a fire being in the pixel. We have tentatively set them as follows: a blank is zero probability, a "1" means probability between 0 and 0.2 or a 20 percent chance of a fire, a '2" is between 0.2 and 0.4 or between 20 and 40 percent, a "3" is between 0.4 and 0.8 or between 40 and 80 percent, and a "4" means that there is a probability greater than 0.8 or 80 percent that there is a fire in the pixel. This coding enables us to put the probabilities in a single number for the pixel. Users who prefer a different coding scheme or levels are welcome to do so, provided the actual calculation of the probabilities is not changed. The values are set in a subroutine within SHOWTIME.

Information on the printout could also represent other variables related to an area on the ground, if the variables can be represented as a single character. The generation of extra information would go into SHOWTIME. A possible use might be a simple fire-danger map, or a rate-of-spread code. To do this, more files and additions to PERIODIC would have to be created.

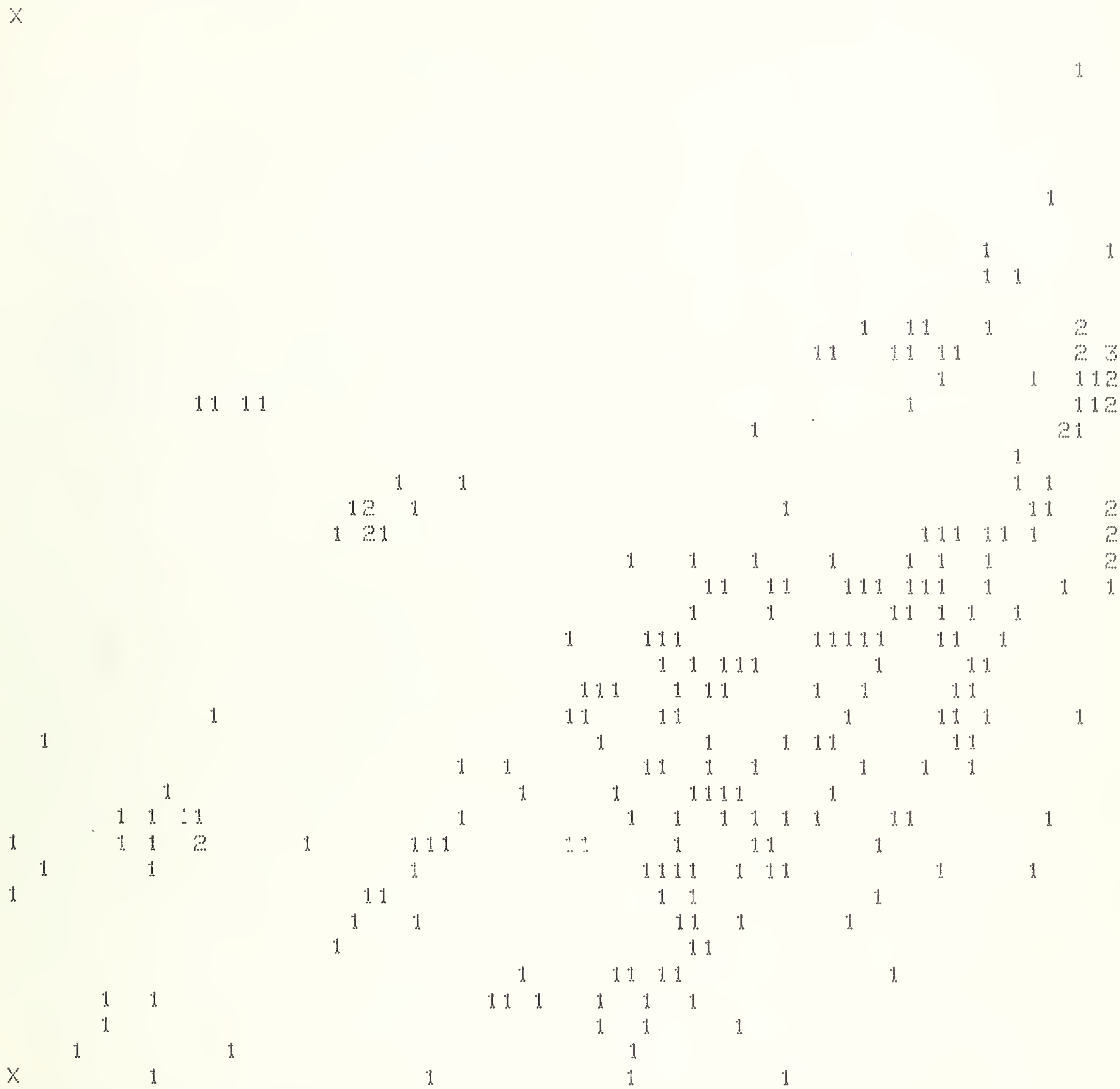
2.5.2 Warning

Research indicates that the accuracy of the lightning ground strike points is not routinely better than the 3 miles we have used for our pixel size. Indeed, in some cases the error may be larger than twice that amount. This means that the lightning locations and fire probabilities may be "off" by at least one pixel, possibly more, in any direction. More research is being done on accuracy.

```
THIS IS THE SOUTHWEST CUMULATIVE LIGHTNING MAP.
THIS MAP COVERS THE PERIOD
FROM :  08/11    11:00    (MDT)
TO   :  08/12    09:40    (MDT)
**************************************************************

X

                                                                   1




                                                                  1

                                                              1      1
                                                              1 1

                                                      1  11   1    2
                                                   13   11 21      2 6
                                                           1    1  113
            11 11                                           2        112
                                               1                  21
                                                                2
                        1   1                                   2 1
                      13  2                      1               11  4
                    1 31                                      311 31 1   6
                                       1   1   1    1    1 1  1      2
                                            12  12   111 312  1    1 1
                                           1    1       11 1 3  1
                                   1    111        11211   11  1
                                         1 2 111       1     21
                                    111   1 12     2  1     41
             1                     11    11          1     11 1    1
  1                                  1      1    1 21       11
                            1  1        11  2  1      1   1  1
          1                     1     2    2111     1
       1 1 11               1          1  2  1 1 1 1    11       1
1      1 2  2      1     111       11     2    11      1
  1      1               1              1112  1 11         1     1
1                     11                 2 1           1
                      1   1               11  2      1
                     1                     21
                                2     12 11             1
      1  1                    11 1   1  2  1
      1                              1  1     1
    2         1                         1
X        1                1            1         1

THERE WERE  296  STRIKES IN THE QUADRANT.
**************************************************************
```

Figure 7.—A typical lightning density map generated by SHOWTIME.

```
THIS IS THE SOUTHWEST CUMULATIVE EXPECTED FIRE MAP.
THIS MAP COVERS THE PERIOD
FROM :   08/11     11:00     (MDT)
TO   :   08/12     09:40     (MDT)
*****************************************************************
```



```
THERE WERE  230  SQUARES EXPECTING FIRES.
*****************************************************************
```

Figure 8.—A typical fire probability map generated by SHOWTIME.

2.6 FIELD USE

The field user (Forest level) will need a set of instructions for use of LLAFFS. The instructions we used for our field trial are included as appendix A. The important elements of these instructions are:

- Dial-up or other access instructions must be clear and detailed; a lot of inquiries and "handholding" will be saved by overkill in the instructions.
- The map areas covered by the printout pixels must be clearly stated and related to familiar geography.
- Overlays must be simple and easily read. More than one overlay map covering the same area is better than a single one with too much information on it.
- The meanings of the numbers on the printouts must be clearly stated.

Overlays for our application are not included in this package because of their cost and provinciality. We have had some success with overlays made from simple hand-drawn maps such as that of figure 9. These are copied using a transparency copier such as those used for making overhead projections. If desired, information to help users with this procedure might be given as part of the field guide. Transparencies may have to be tailored for use with varying kinds of terminals, because terminal print sizes are variable. If the users are using only one terminal or one kind of terminal, this tailoring will not be necessary.

Appendix B contains a sample user run of the LLAFFS output. The message section at the beginning of the run is generated by the operating system of our host computer. If this is desired in other implementations, it could be part of SHOWTIME. To avoid modifying the program each time the message is to be changed, put the message in a file and access it in the SHOWTIME program.

2.7 CONCLUSION

The programs which are included in this package were all developed in BASIC for use on a Perkin-Elmer 3200 machine. Adaptation to other computers may require some program rewriting. In particular, file handling syntax may be considerably different. Smaller machines may require more intermediate files because of memory limitations. It may also be desirable to automate the map output instead of having a dial-in system. See also the comments in sections 1.1 and 2.2.4.

NOTE: Portions of the programs having to do with probability calculation must not be changed without consultation. To make such changes will invalidate the predictions. If this warning is heeded, the system presented in this package will improve the use of lightning location networks for fire management.

OVERLAY NO.1 NORTHWEST

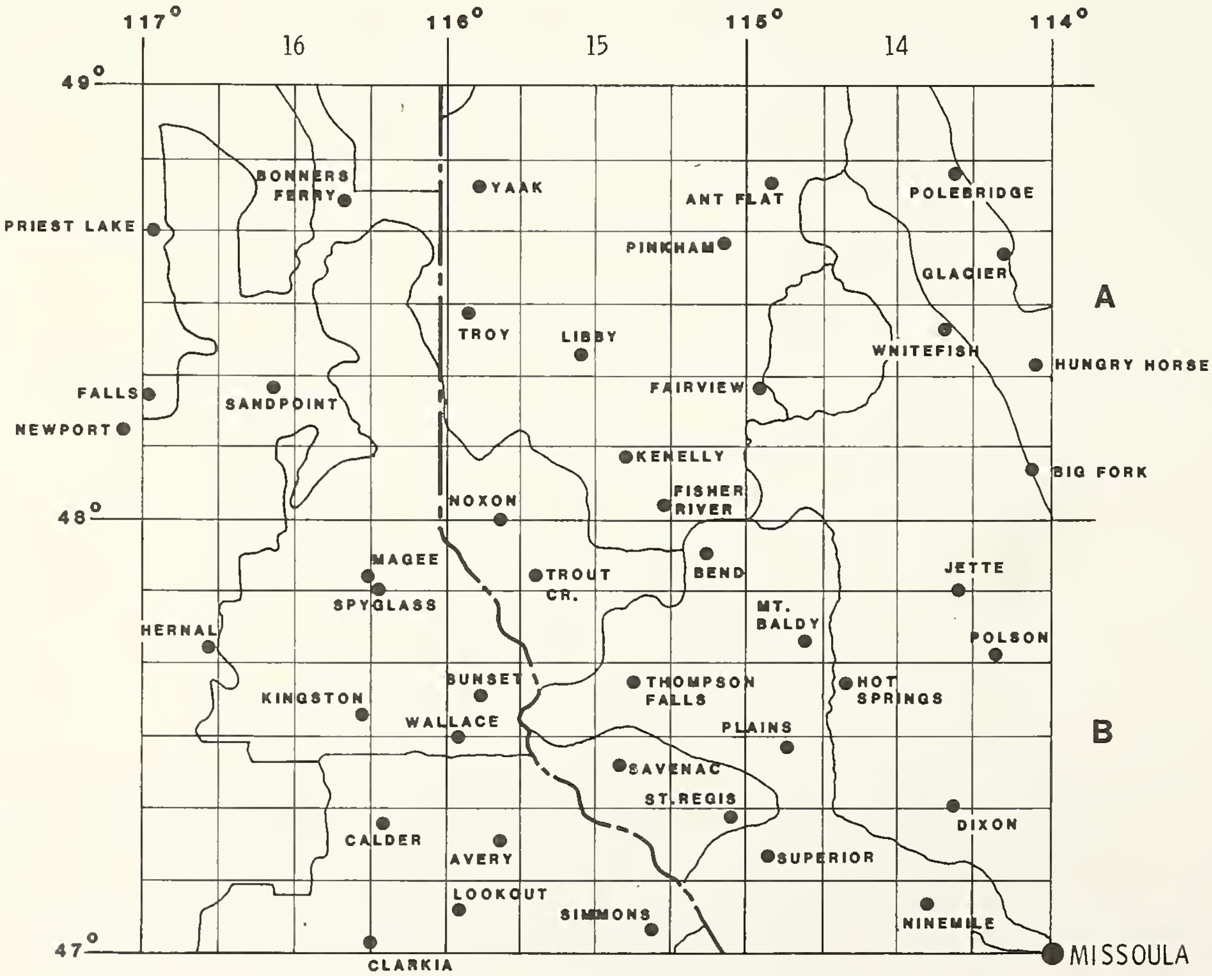


Figure 9.—A sample overlay map.

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APPENDIX A
SAMPLE INSTRUCTIONS*

Dialin Lightning

This is the instruction sheet for using experimental lightning location and fire probability maps. The maps are a joint effort between Aviation and Fire Management of Region 1 and the Intermountain Forest and Range Experiment Station, Northern Forest Fire Laboratory. Our objective is to make available both current and cumulative information on lightning occurrence and probable fire starts. The information is in the form of simple printouts designed to be used with a Regional overlay map. The computer that generates the printouts is located at the Fire Laboratory. The Regional Coordinator's office plans to alert users through the Weather teletype network, and distribute the maps and instructions for use. The printouts can be obtained using a 300-baud printing terminal, such as an Execuport. The terminal may have either 80 or 132 print columns. The printouts, an example of which accompanies these instructions, are designed to be used with the overlay maps, also supplied.

The Regional overlay map has been divided into four quadrants: NW, NE, SW, and SE. The center of the quadrants is at 47 degrees north latitude and 114 degrees west longitude. Each quadrant covers two degrees in latitude and three in longitude:

NORTHWEST: 47–49 N and 114–117 W, includes part or all of the Kaniksu, Kootenai, Flathead, Coeur D'Alene, Lolo, and St. Joe Forests,

NORTHEAST: 47–49 N and 111–114 W, includes the Flathead, Lewis and Clark, Lolo, and Helena Forests,

SOUTHWEST: 45–47 N and 114–117 W, includes the St. Joe, Clearwater, Lolo, Nezperce, and Bitterroot Forests,

SOUTHEAST: 45–47 N and 111–114 W, includes the Lolo, Helena, Deerlodge, Beaverhead, and Gallatin Forests.

The printouts are made with an X in each of the upper and lower left-hand corners. These are to be aligned with the leftmost top and bottom boundary corners of the appropriate quadrant of the overlay map. For example, if the quadrant on the printout is the NE, the top X goes under 49N, 114W and the bottom X under 47N, 114W and so on. Those of you with map experience will note that the registration of the overlay and the map is not perfect. That is because the printouts are "flat earth" and the maps are projections. Expect errors of at least one pixel (that is jargon for one character space on the printout map) in all directions, and more toward the top of the upper half of the overlay and the bottom of the lower half.

*Note: These sample instructions are from an experiment and are for user guidelines only. Telephone numbers are now different, and LLAFFS is no longer experimental.

There are 16 available printout maps, 4 for each quadrant. These are:

- a lightning occurrence map updated each half-hour,
- a cumulative lightning map, beginning each day at 0400 hours,
- a fire probability map updated each half hour, and
- a cumulative fire probability map, beginning each day at 0400 hours. The numbers on the lightning maps represent the number of discharges to the area represented by that pixel (one character space), for both the 1-hour and the cumulative maps.

The fire probability maps have been scaled. The probability of fire for each pixel is reduced to a single number from zero to four. The zeroes are not printed for better clarity. These characters do not translate directly into numbers of fires. That is, a "1" in a pixel does not mean one fire in that area, rather a low but not zero probability of a fire. The same is true for a "2", and so on. The larger the number, the greater the chance that there is a fire near the area represented by the pixel. Remember that this area is larger than it appears because of the accuracy limitations of the equipment and the overlay display technique.

Now, how can you get the maps? That is the easy part. First, get hold of a 300-baud terminal that can hook up to a phone line. Then, dial 329-3870, commercial, or 585-3870, FTS. When you hear the tone, stick the phone in the terminal (if it is that kind). Type a few letters and hit return; the message *SIGNON REQUIRED should appear. If it does not, the computer is down or the terminal is not making contact. Try once more, and if there is no response, the computer is probably down.

If the message *SIGNON REQUIRED, followed by a new line beginning with an *, is received, type in SIGNON ID,125,LTNG, then return. Do not forget the commas, and do not leave any spaces except for one after the word SIGNON. Put the forest ID initials in position ID or some other ID letters for other users. Do not use numbers. ID may be from one to four letters long. The computer will respond with the program SHOWTIME, which begins with the date and time and should proceed as shown in the examples we have provided. Some time may elapse before the response, but a minus sign (–) will appear right away to show that you are hooked up. If you have difficulties and have struggled with them for a while, call us at 585-3494, FTS, or 329-3494, commercial. If the computer is down, try later.

Please remember that this is an experiment. We are not staffed for a 7-day week, 24-hour day, but we will do the best we can. We would like to have your comments. Either pass them through the Regional dispatch center or send them directly to Don Latham at the Northern Forest Fire Laboratory. We are especially interested in documented comments regarding accuracy.

APPENDIX B
A SAMPLE FIELD RUN OF LLAFFS

```
SIGNON DON,125,LTNG
SIGNON REQUIRED
*SIGNON DON,125,LTNG
-
-08/12/82  10:24:32
-
- LIGHTNING LOCATION AND FIRE FORECAST SYSTEM  (LLAFFS)
-
-NEWS -- 08/11/82
-ALL SYSYTEMS GO.
-
-WHICH QUADRANT WOULD YOU LIKE TO SEE ?  (NW,NE,SW,SE)
>SW

   OPTIONS
     LIGHTNING MAPS
      1. LAST HALF HOUR
      2. CUMULATIVE
     EXPECTED FIRE MAPS
      3. LAST HALF HOUR
      4. CUMULATIVE
     OTHERS
      5. 1 AND 2
      6. 3 AND 4
      7. 2 AND 4
ENTER AN OPTION NUMBER
>7
```

```
THIS IS THE SOUTHWEST CUMULATIVE LIGHTNING MAP.
THIS MAP COVERS THE PERIOD
FROM :  08/11    11:00    (MDT)
TO   :  08/12    09:40    (MDT)
***************************************************************

X

                                                                    1




                                                                  1

                                                              1       1
                                                              1 1

                                                      1  11   1     2
                                                    13  11 21       2 6
                                                           1     1  113
            11 11                                          2          112
                                               1                   21
                                                                2
                         1   1                                  2 1
                      13  2                      1               11   4
                     1 31                                 311 31 1    6
                                        1   1   1    1   1 1  1       2
                                             12  12  111 312  1    1  1
                                            1    1      11 1 3  1
                                    1    111        11211  11  1
                                          1 2 111       1    21
                                     111   1 12     2  1    41
             1                      11    11          1    11 1     1
  1                                   1      1    1 21      11
                             1  1        11  2  1     1   1  1
          1                      1     2    2111     1
       1 1 11                1          1  2  1 1 1 1    11       1
1      1 2  2      1      111       11     2    11      1
  1      1                1              1112  1 11        1     1
1                      11                 2 1           1
                      1   1                11  2      1
                     1                      21
                                 2     12 11            1
      1  1                     11 1   1  2  1
      1                               1  1     1
    2         1                         1
X        1                 1            1         1

THERE WERE  296  STRIKES IN THE QUADRANT.
***************************************************************
```

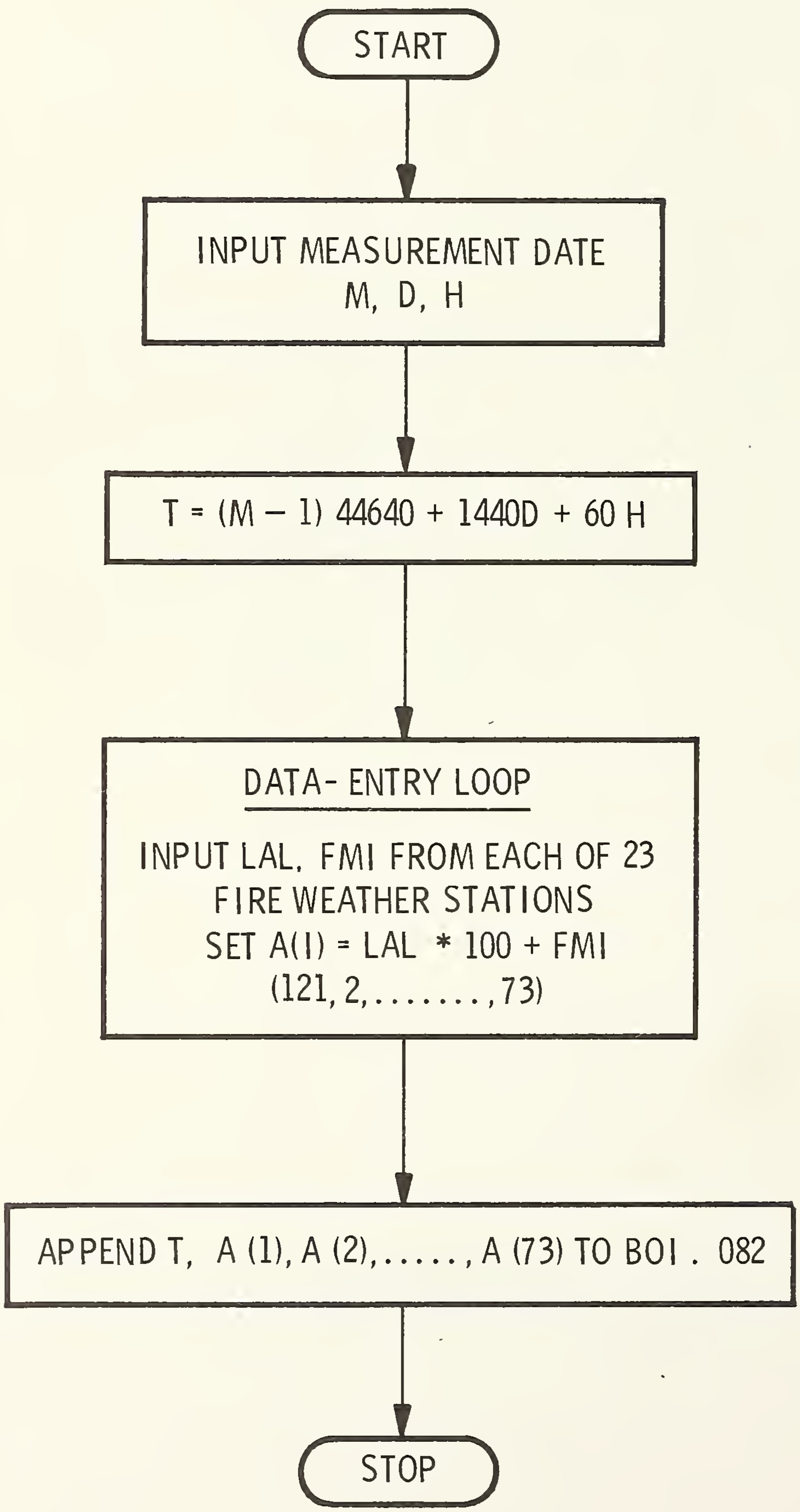
```
THIS IS THE SOUTHWEST CUMULATIVE EXPECTED FIRE MAP.
THIS MAP COVERS THE PERIOD
FROM :  08/11    11:00    (MDT)
TO   :  08/12    09:40    (MDT)
***************************************************************

X

                                                                     1




                                                                   1

                                                               1       1
                                                               1 1

                                                       1  11   1     2
                                                    11   11 11       2 3
                                                            1     1  112
            11 11                                             1          112
                                                1                   21
                                                                 1
                         1   1                                   1 1
                      12  1                       1               11   2
                     1 21                                  111 11 1    2
                                        1   1   1    1    1 1  1       2
                                             11  11   111 111  1    1  1
                                            1    1       11 1 1  1
                                    1    111        11111   11  1
                                          1 1 111       1     11
                                     111   1 11     1  1     11
             1                      11    11          1     11 1     1
  1                                    1      1    1 11       11
                             1  1        11  1  1      1   1  1
          1                      1     1    1111     1
       1 1 11                1          1  1  1 1 1 1    11        1
1      1 1  2      1      111       11     1    11      1
  1      1                1              1111  1 11         1     1
1                      11                 1 1           1
                      1   1                1  11  1      1
                     1                      11
                                 1     11 11             1
      1  1                     11 1   1  1  1
      1                               1  1     1
    1         1                         1
X        1                 1            1         1

THERE WERE  230  SQUARES EXPECTING FIRES.
***************************************************************

MORE MAPS ?  (Y OR N)
>Y
WHICH QUADRANT   (NW,NE,SW,SE)
>SW
OPTION NUMBER
>7
```

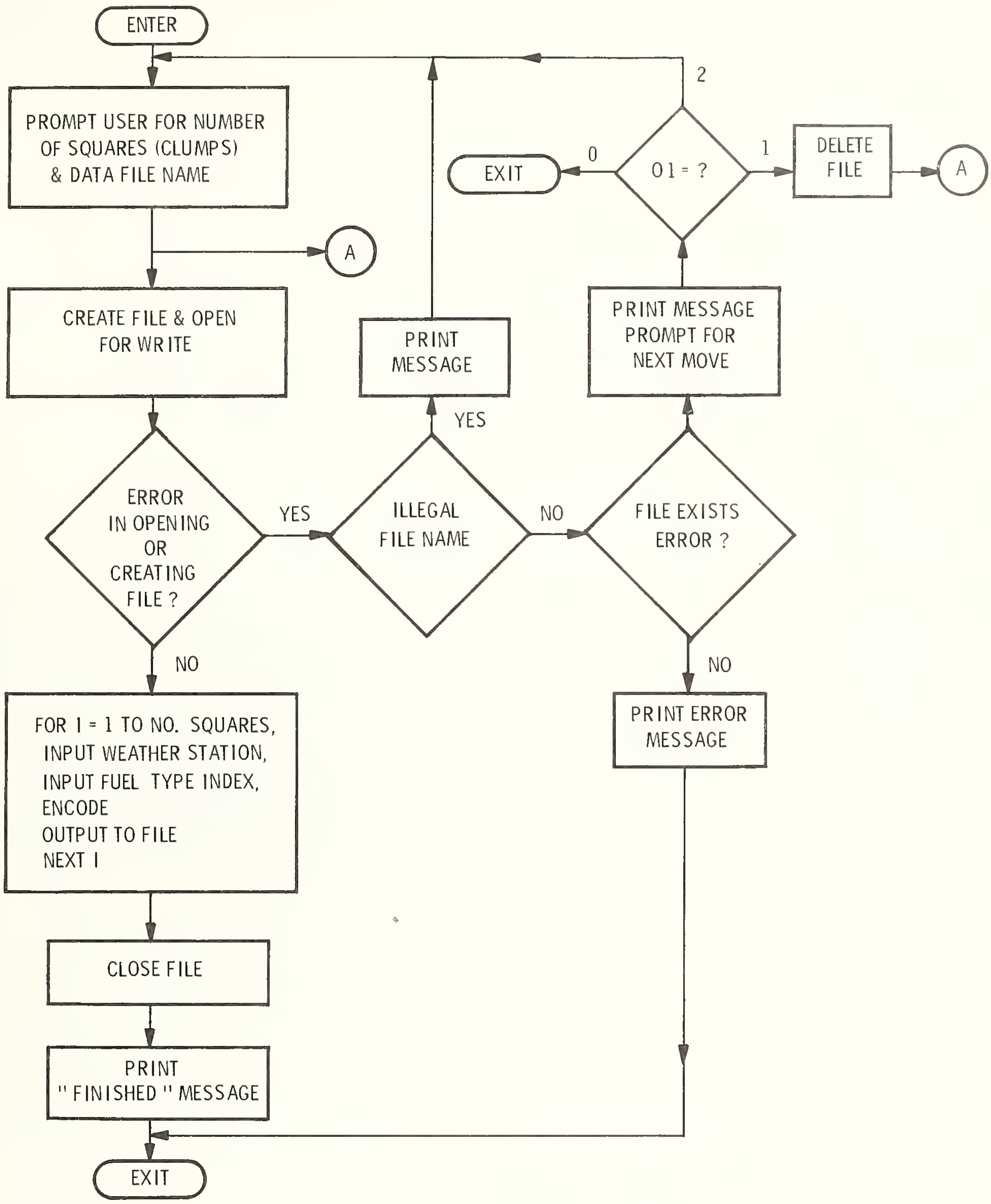
```
THIS IS THE SOUTHEAST CUMULATIVE LIGHTNING MAP.
THIS MAP COVERS THE PERIOD
FROM :  08/11    11:00    (MDT)
TO   :  08/12    09:40    (MDT)
****************************************************************

X                 11          1  1                                 1
            1   3 1     1 1    22   1                            1    1
                      11       1             1                    1  11
           11 111      4    1  21       1
             1        11      21           1  1                       1
              1  1 1   11 1 11          1
1           1     2   1     1
       2 11 32     2  1               1                          1 111 1
         1144         1               1                      1
      1  1   1   1 1                                                 1
  1                1          1                            111 2 1
   2 11     1      2          1                          1 2 2211
   12     11     1221                                     21  1
 1        1  1      2         1 2221                 1 322 1   2       2
    1            2 1    111         1            1 3     1 1
           22          1         1               112  1       1
2   1     1                   1           1         13211 1 1
  11 1  111                 1    1            3     3   1
2  1                           1                1  1
                                      1      1       1  1 2
31   11         1              1       1  1  2 1   1   1 11 1
212  2                           1            12 21 1       2 1
               1                       22    1   11   11
                                1      1111         1
                               1 1    3   1
                                            1  1                       1
       1                                                 1
             1                                           1
             1
                                             1
                                                1     1

             1
                                                 1  1
                                                    1



                        1


X                                                               1 1

THERE WERE  313  STRIKES IN THE QUADRANT
****************************************************************
```

```
THIS IS THE SOUTHEAST CUMULATIVE EXPECTED FIRE MAP.
THIS MAP COVERS THE PERIOD
FROM :  08/11    11:00    (MDT)
TO   :  08/12    09:40    (MDT)
****************************************************************

X                 11          1  1                                 1
            1   2 1     1 1    11   1                            1    1
                      11       1             1                    1  11
           11 111      1    1  11       1
             1        11      11           1  1                       1
              1  1 1   11 1 11          1
1           1     1   1     1
       1 11 11     2  1               1                          1 111 1
         1111         1               1                      1
      1  1   1   1 1                                                 1
  1                1          1                            111 1 1
   1 11     1      1          1                          1 1 1111
   11     11     1111                                     11  1
 1        1  1      1         1 1111                 1 111 1   1       1
    1            1 1    111         1            1 1     1 1
           11          1         1               111  1       1
1   1     1                   1           1         11211 1 1
  11 1  111                 1    1            1     2   1
1  1                           1                1  1
                                      1      1       1  1 2
11   11         1              1       1  1  1 1   1   1 11 1
111  1                           1            12 21 1       2 1
               1                       11    1   11   11
                                1      1111         1
                               1 1    1   1
                                            1  1                       1
       1                                                 1
             1                                           1
             1
                                             1
                                                1     1

             1
                                                 1  1
                                                    1



                        1


X                                                               1 1

THERE WERE  243  SQUARES EXPECTING FIRES.
****************************************************************
```

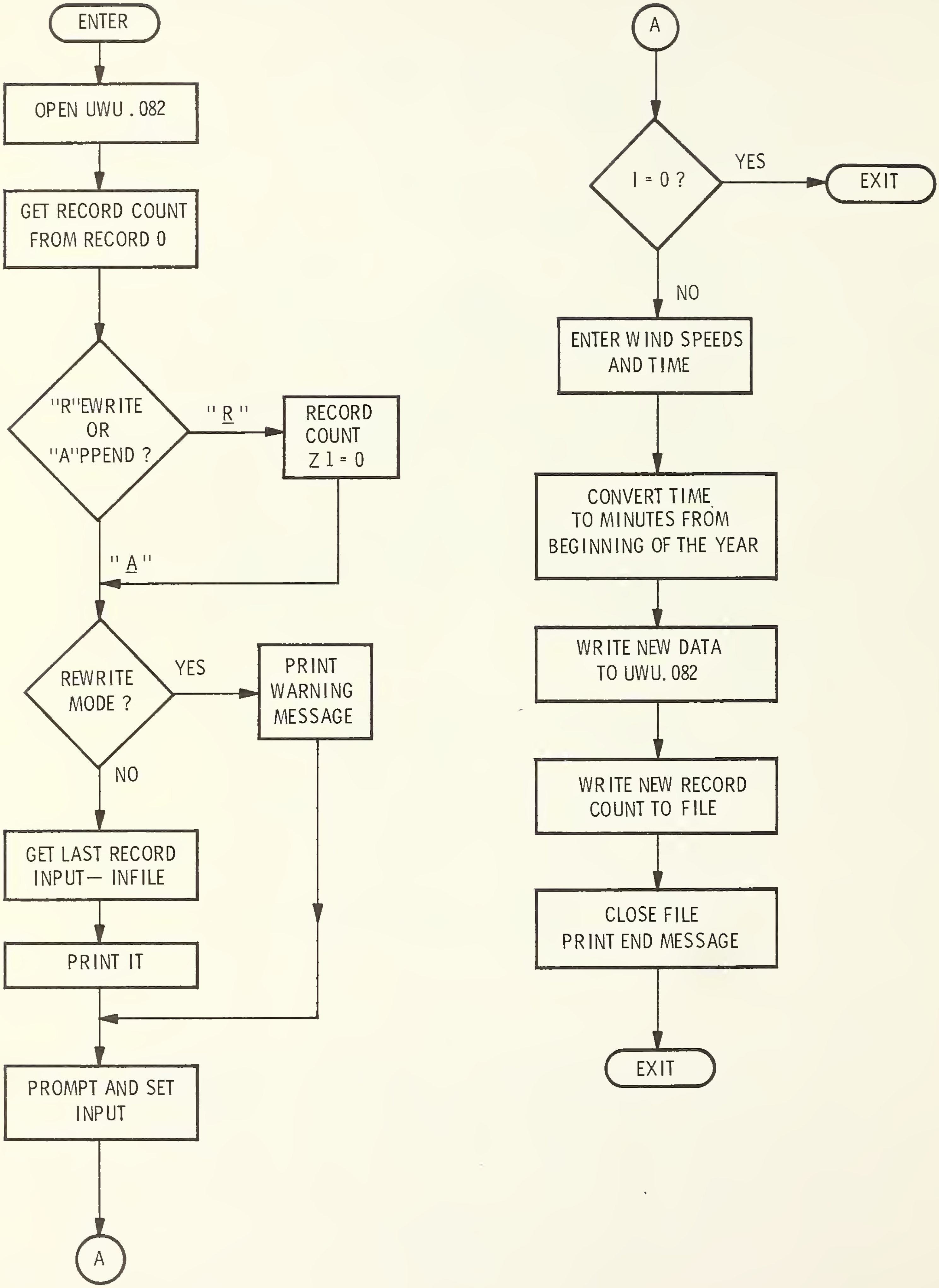
APPENDIX C
FLOW CHARTS AND PROGRAMS

AFFIRMS DATA UPDATER

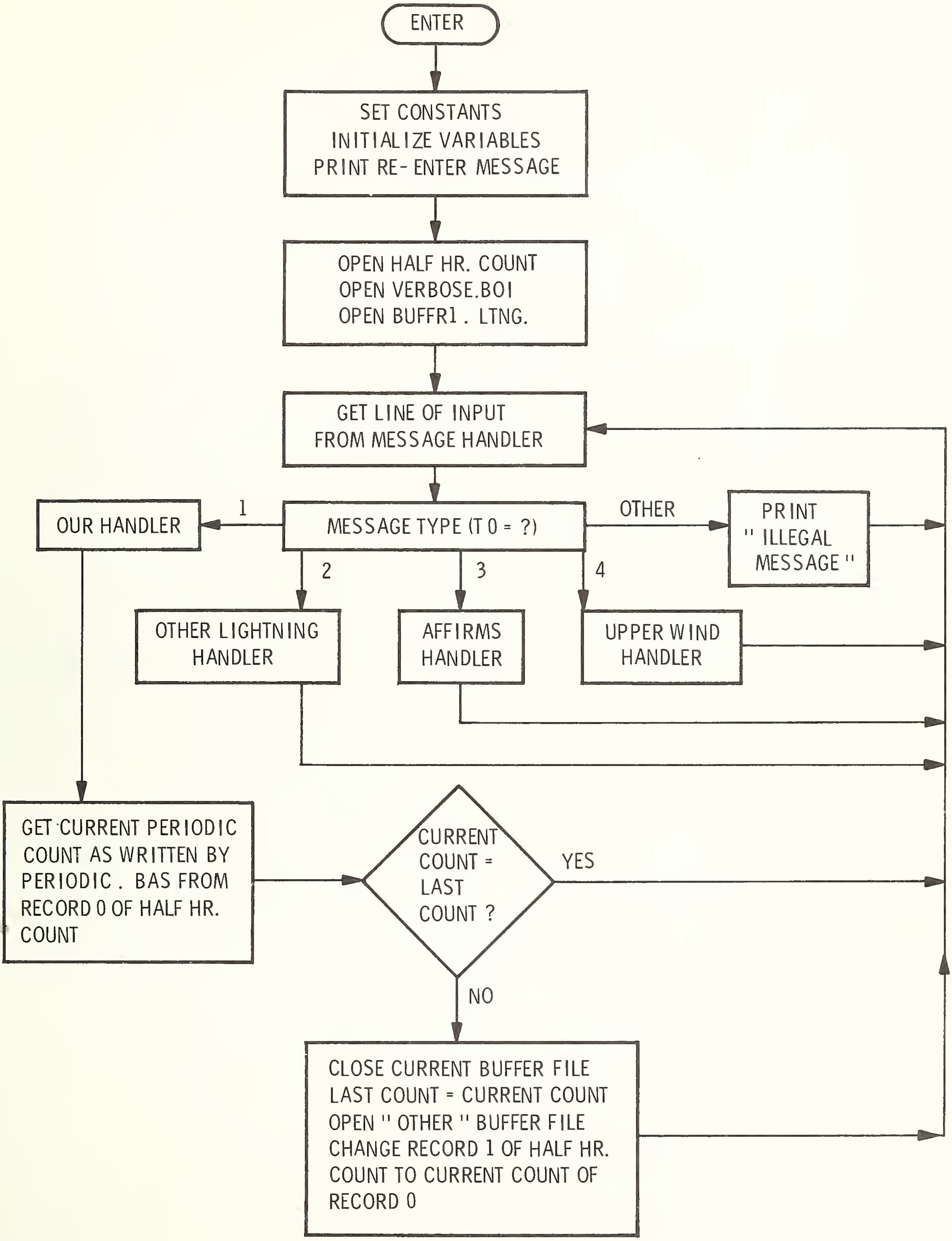



ENTER
PROMPT USER FOR NUMBER OF SQUARES (CLUMPS) & DATA FILE NAME
A
CREATE FILE & OPEN FOR WRITE
ERROR IN OPENING OR CREATING FILE ?
YES
ILLEGAL FILE NAME
YES
PRINT MESSAGE
NO
FILE EXISTS ERROR ?
PRINT MESSAGE PROMPT FOR NEXT MOVE
O1 = ?
2
0
EXIT
1
DELETE FILE
A
NO
PRINT ERROR MESSAGE
NO
FOR I = 1 TO NO. SQUARES, INPUT WEATHER STATION, INPUT FUEL TYPE INDEX, ENCODE OUTPUT TO FILE NEXT I
CLOSE FILE
PRINT "FINISHED" MESSAGE
EXIT

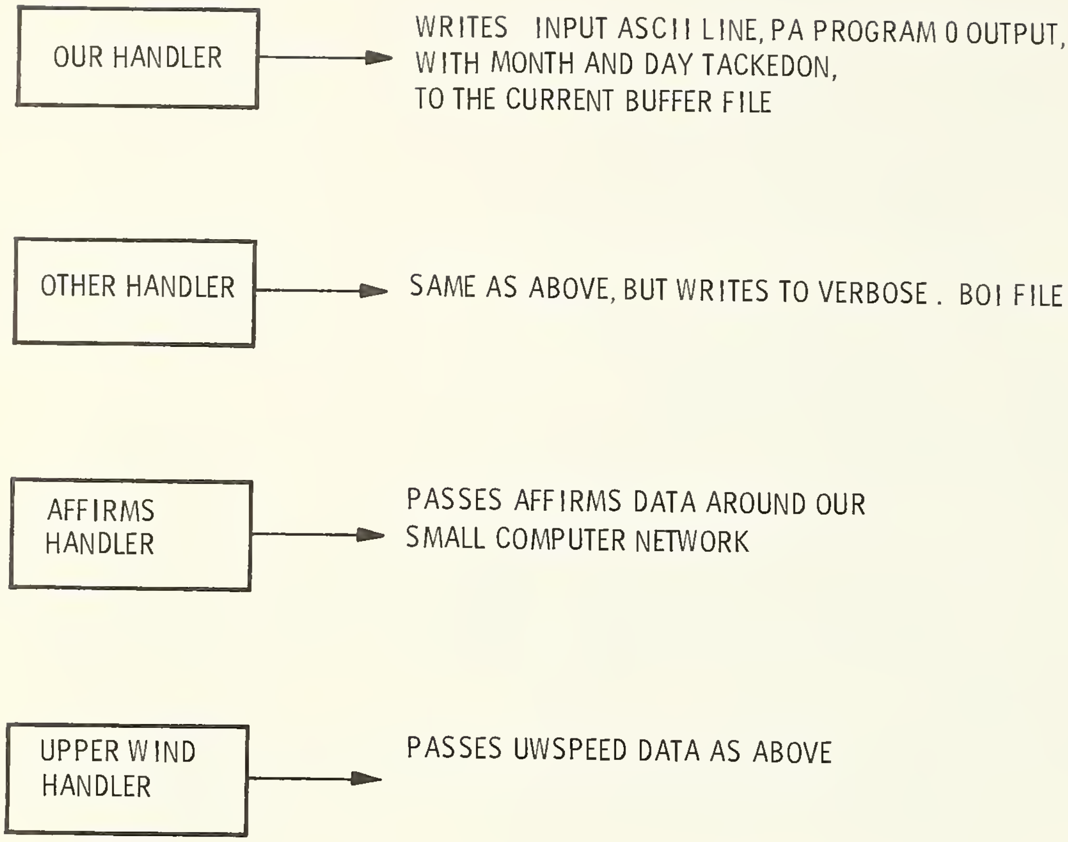
UWU. BAS


ENTER
OPEN UWU . 082
GET RECORD COUNT FROM RECORD 0
"R"EWRITE OR "A"PPEND ?
"R"
RECORD COUNT Z1 = 0
"A"
REWRITE MODE ?
YES
PRINT WARNING MESSAGE
NO
GET LAST RECORD INPUT— INFILE
PRINT IT
PROMPT AND SET INPUT
A
A
I = 0 ?
YES
EXIT
NO
ENTER WIND SPEEDS AND TIME
CONVERT TIME TO MINUTES FROM BEGINNING OF THE YEAR
WRITE NEW DATA TO UWU. 082
WRITE NEW RECORD COUNT TO FILE
CLOSE FILE PRINT END MESSAGE
EXIT

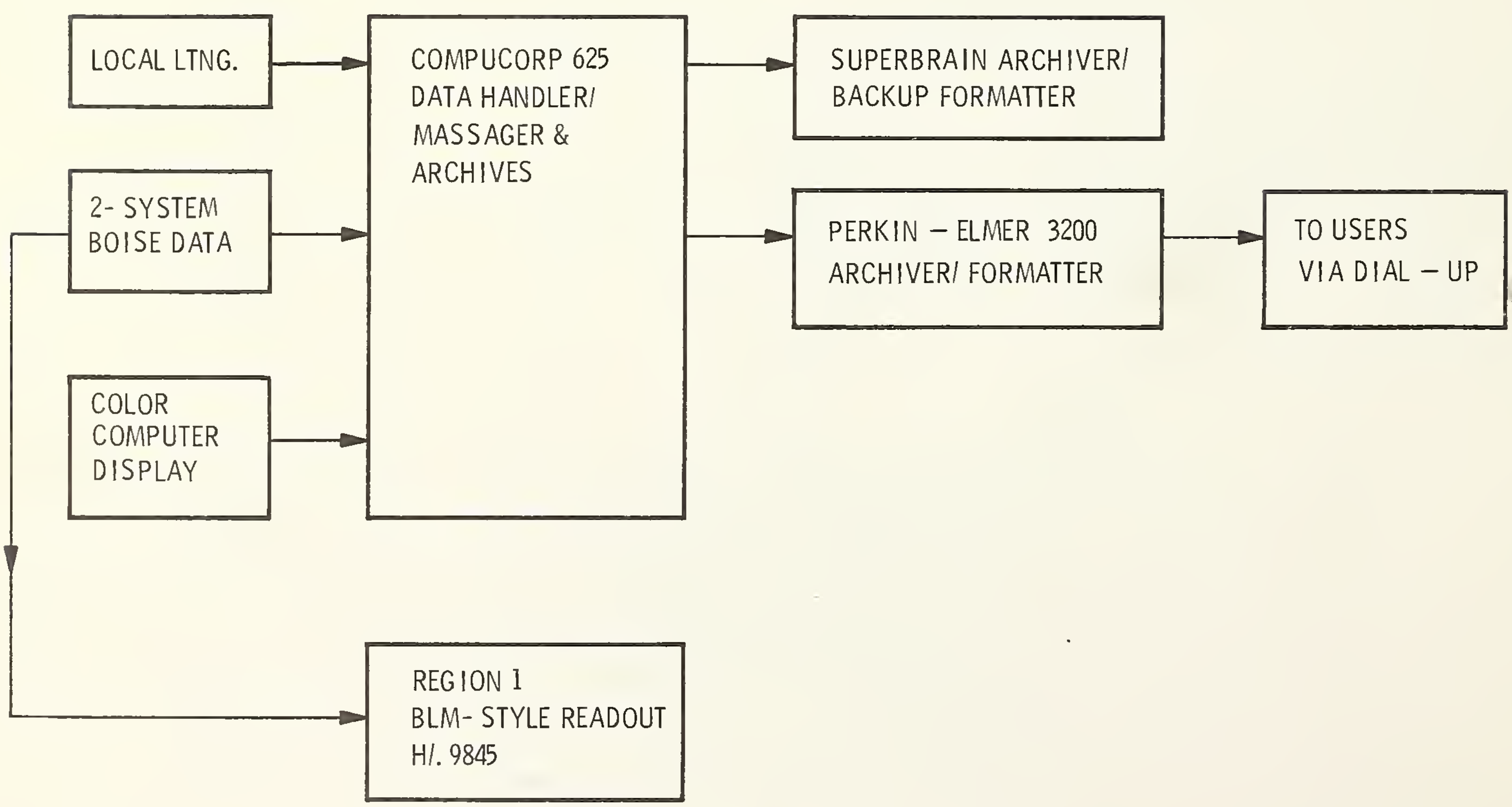
SUPERMON . BAS



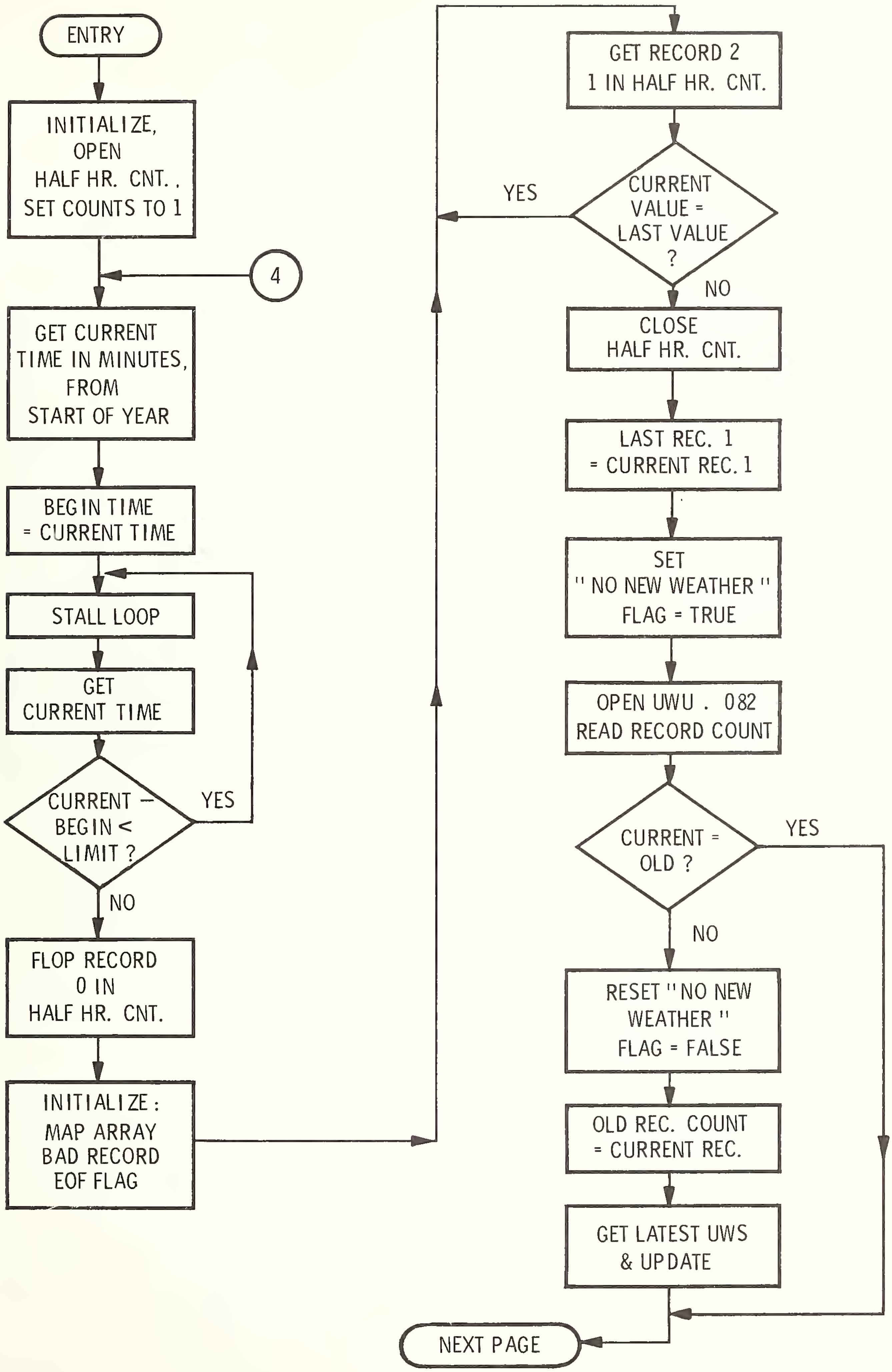
SUPERMON. BAS
(Page 2)



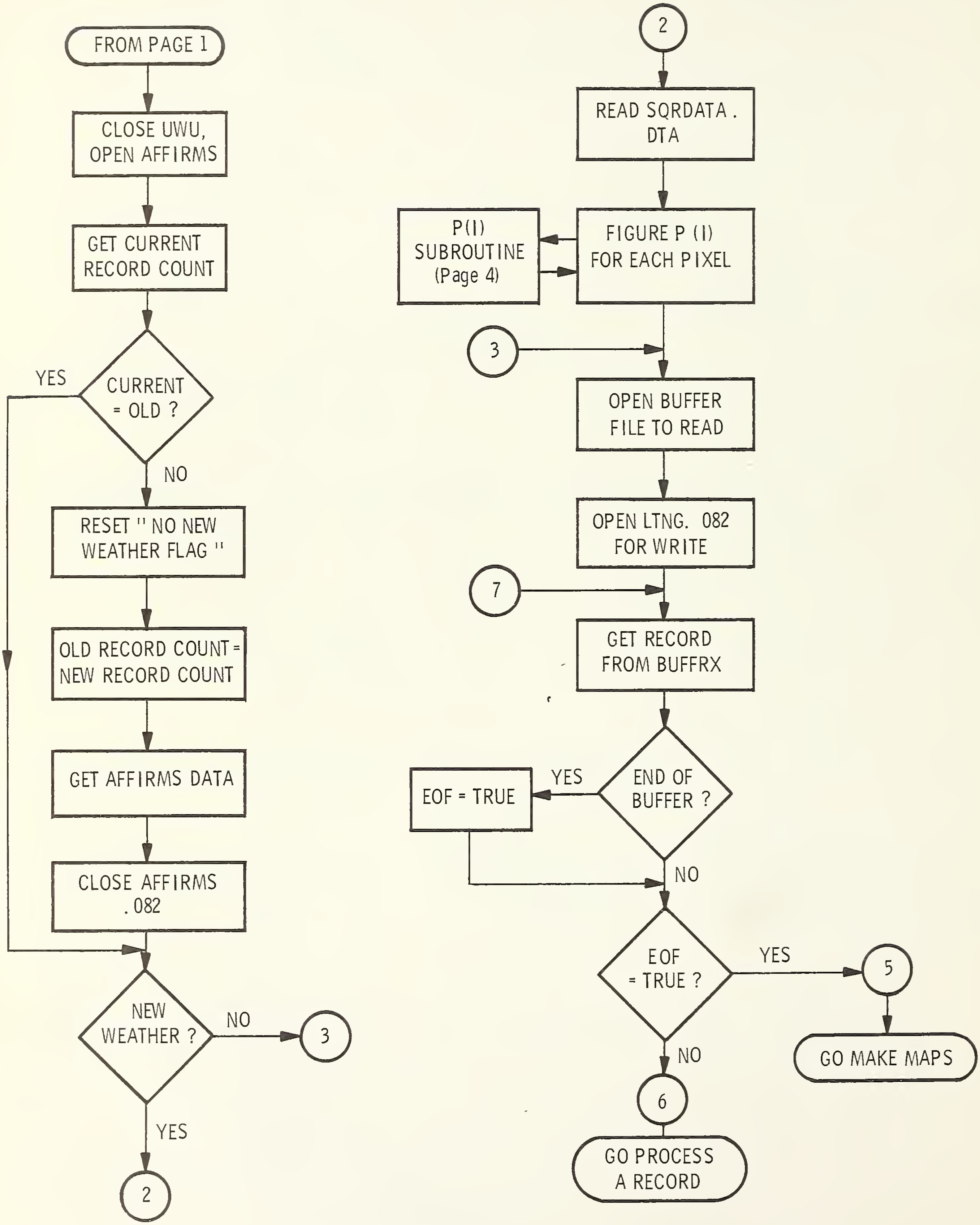
OUR NETWORK



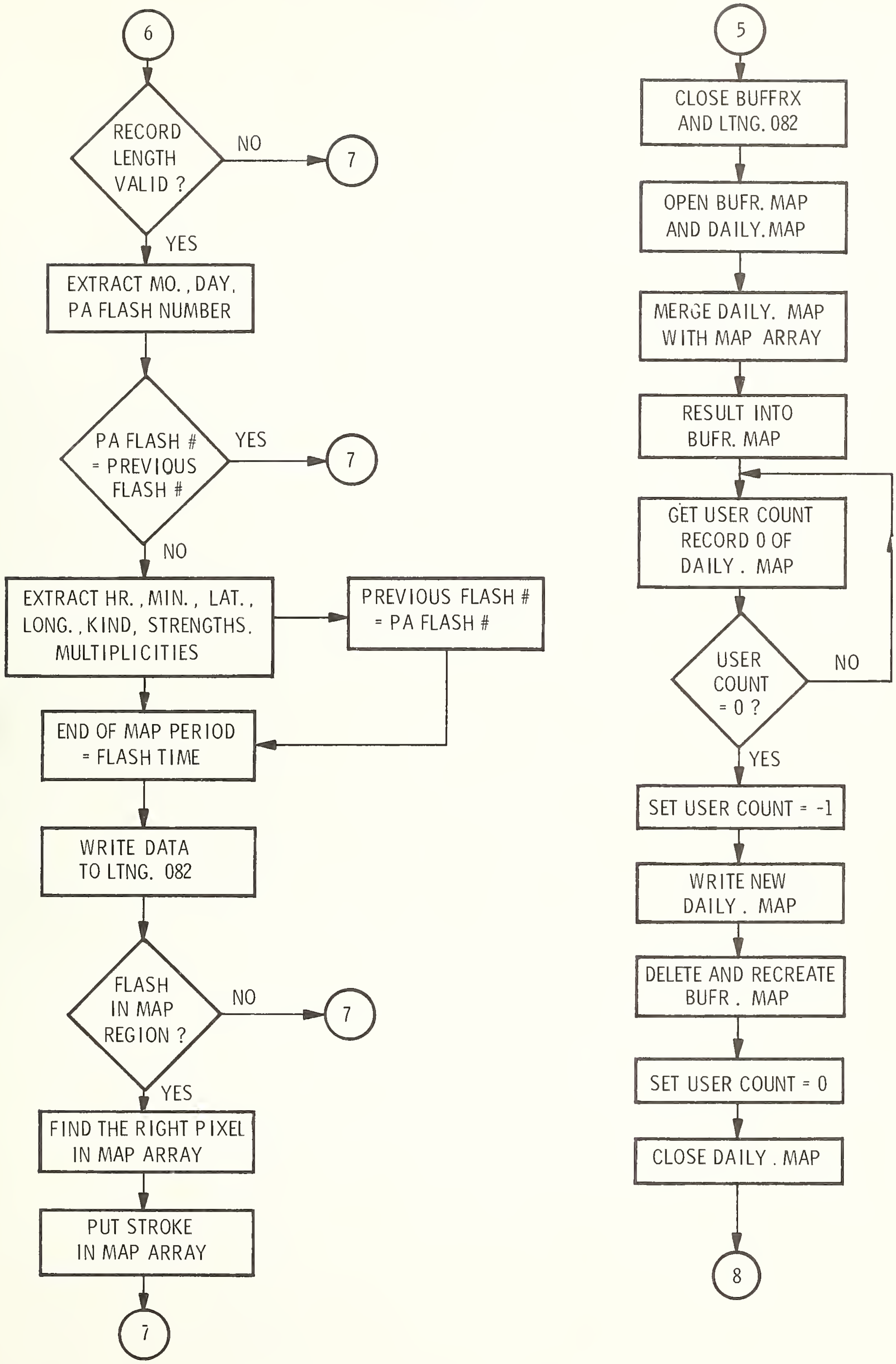
PERIODIC . BAS
(Page 1)



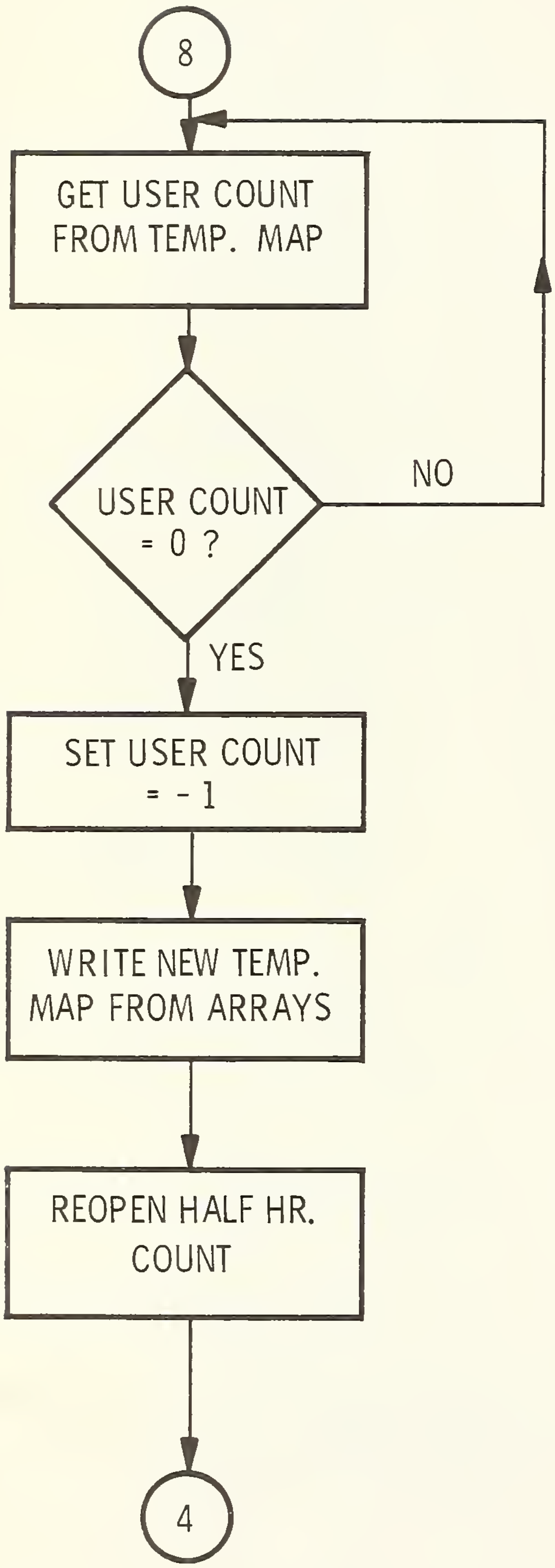
PERIODIC . BAS
(Page 2)

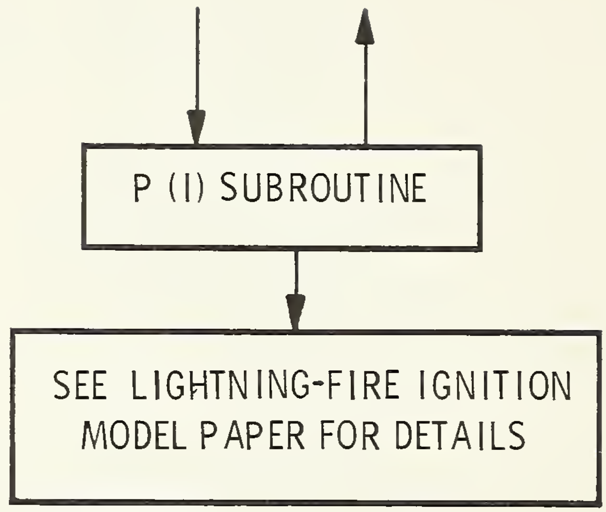


PERIODIC. BAS
(Page 3)

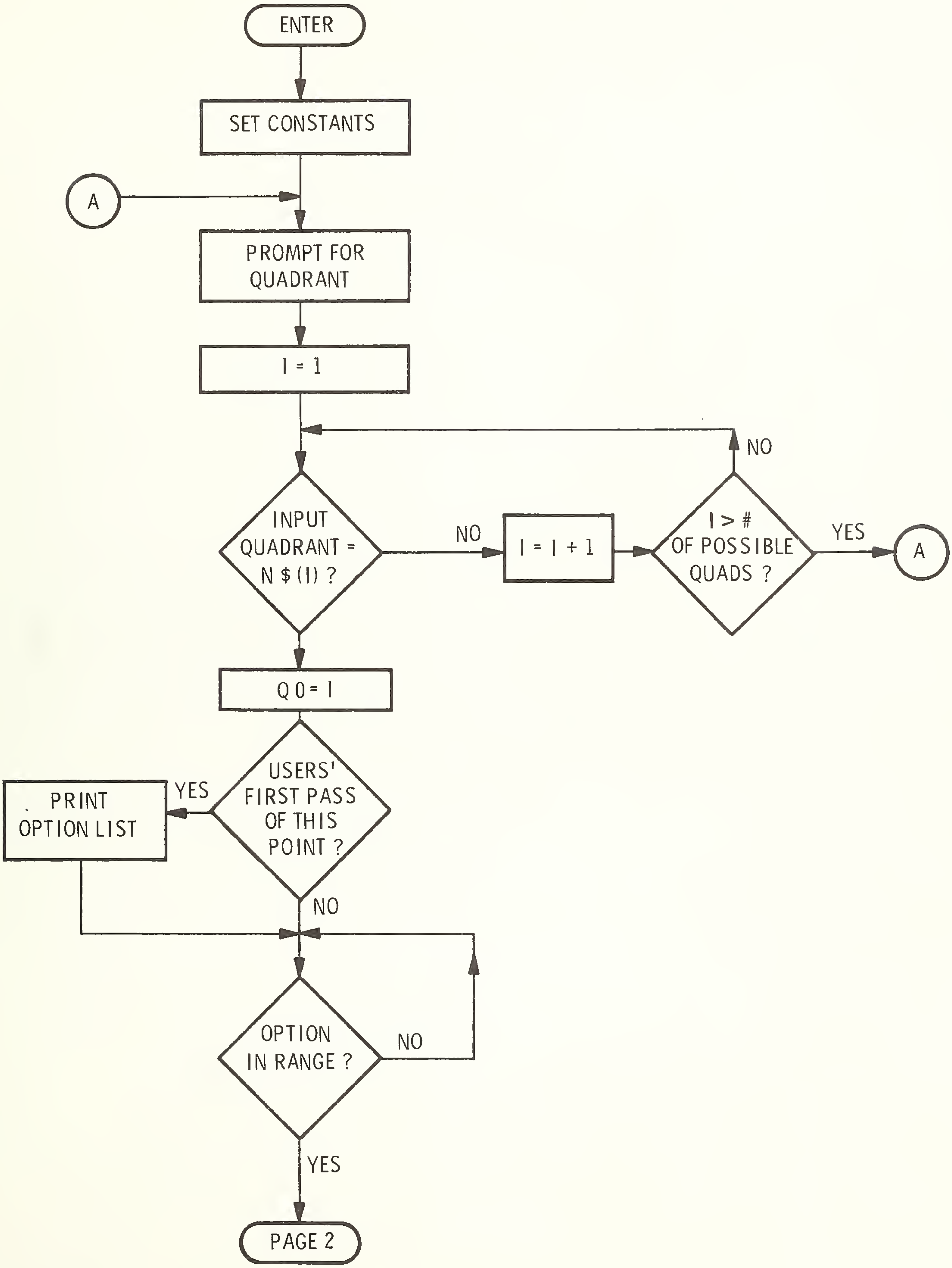


PERIODIC. BAS
(Page 4)

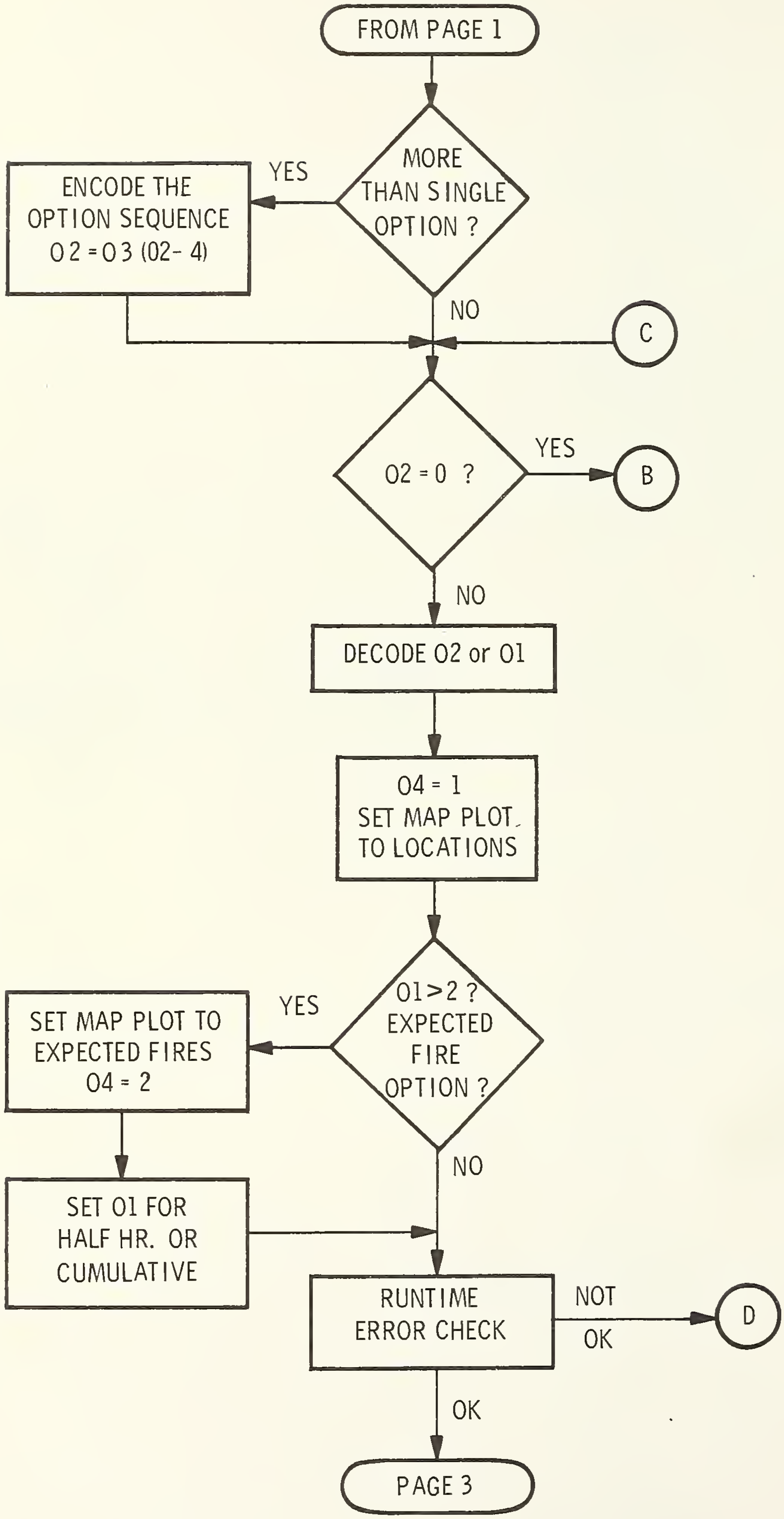




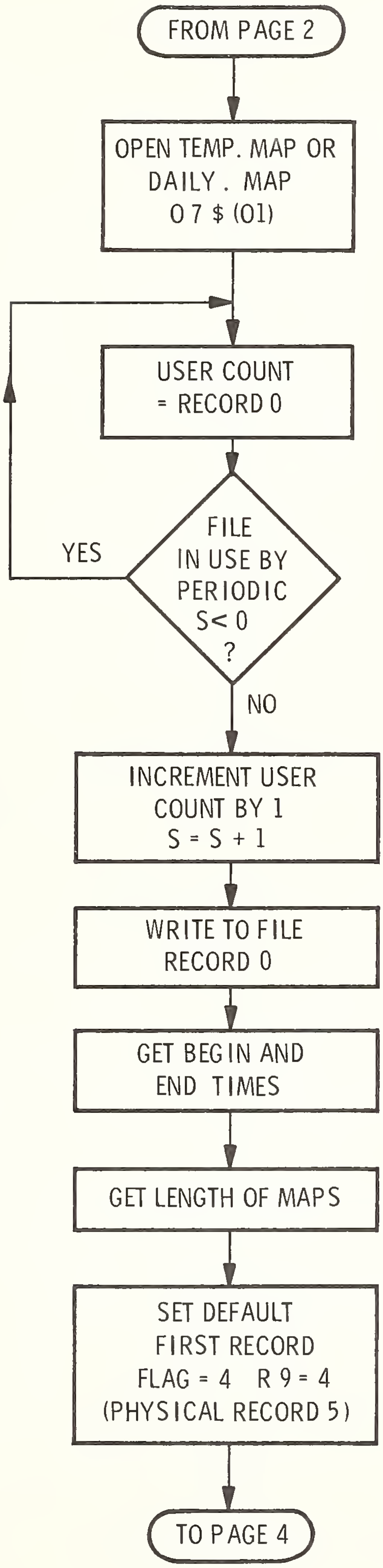
SHOWTIME. BAS
(Page 1)



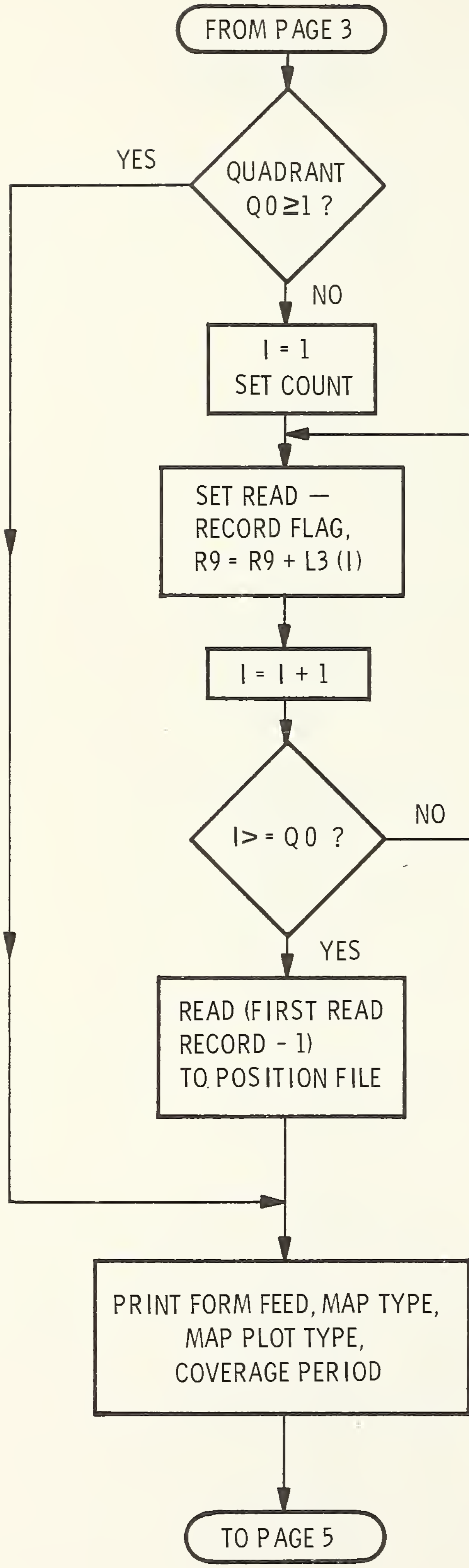
SHOWTIME. BAS
(Page 2)



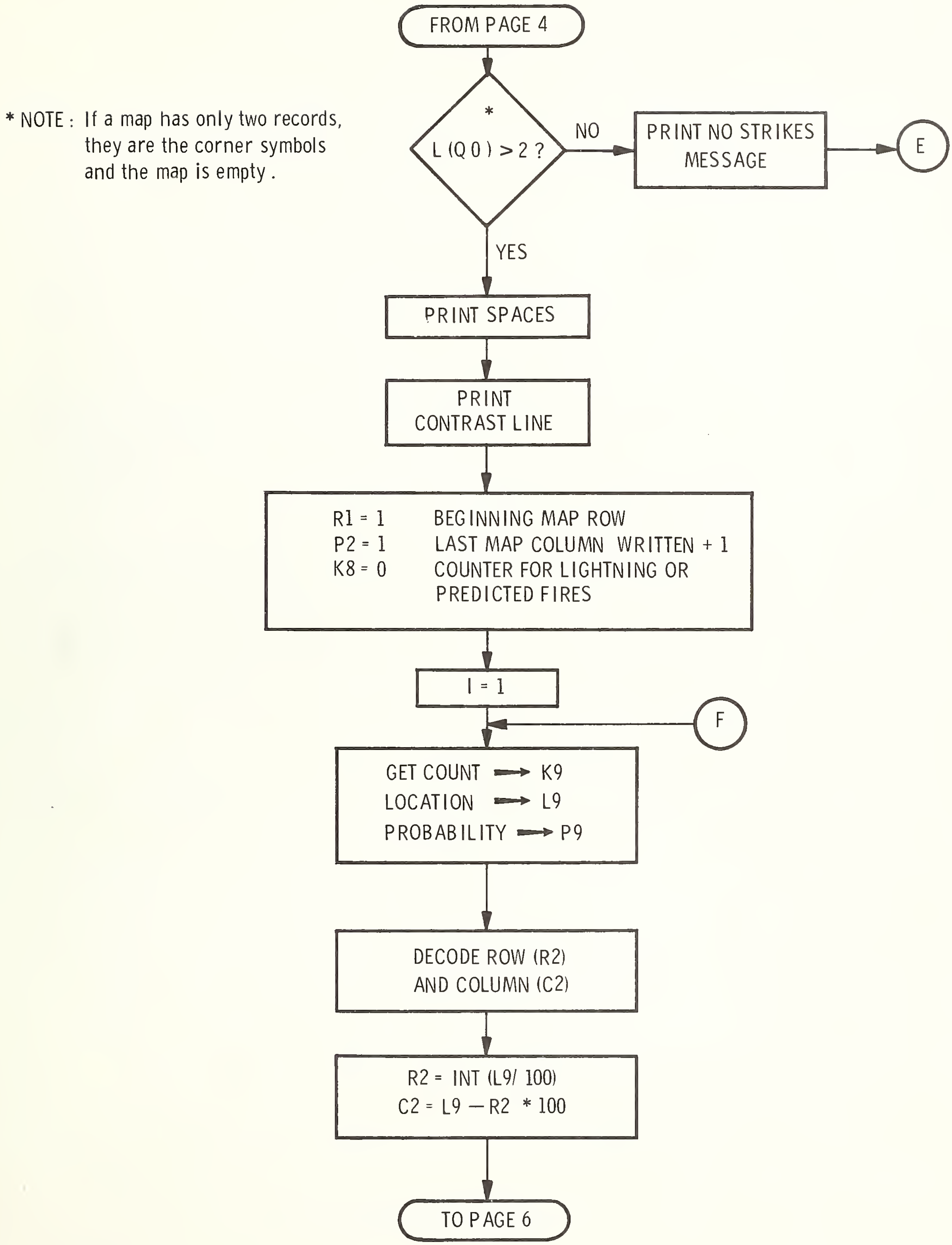
SHOWTIME. BAS
(Page 3)



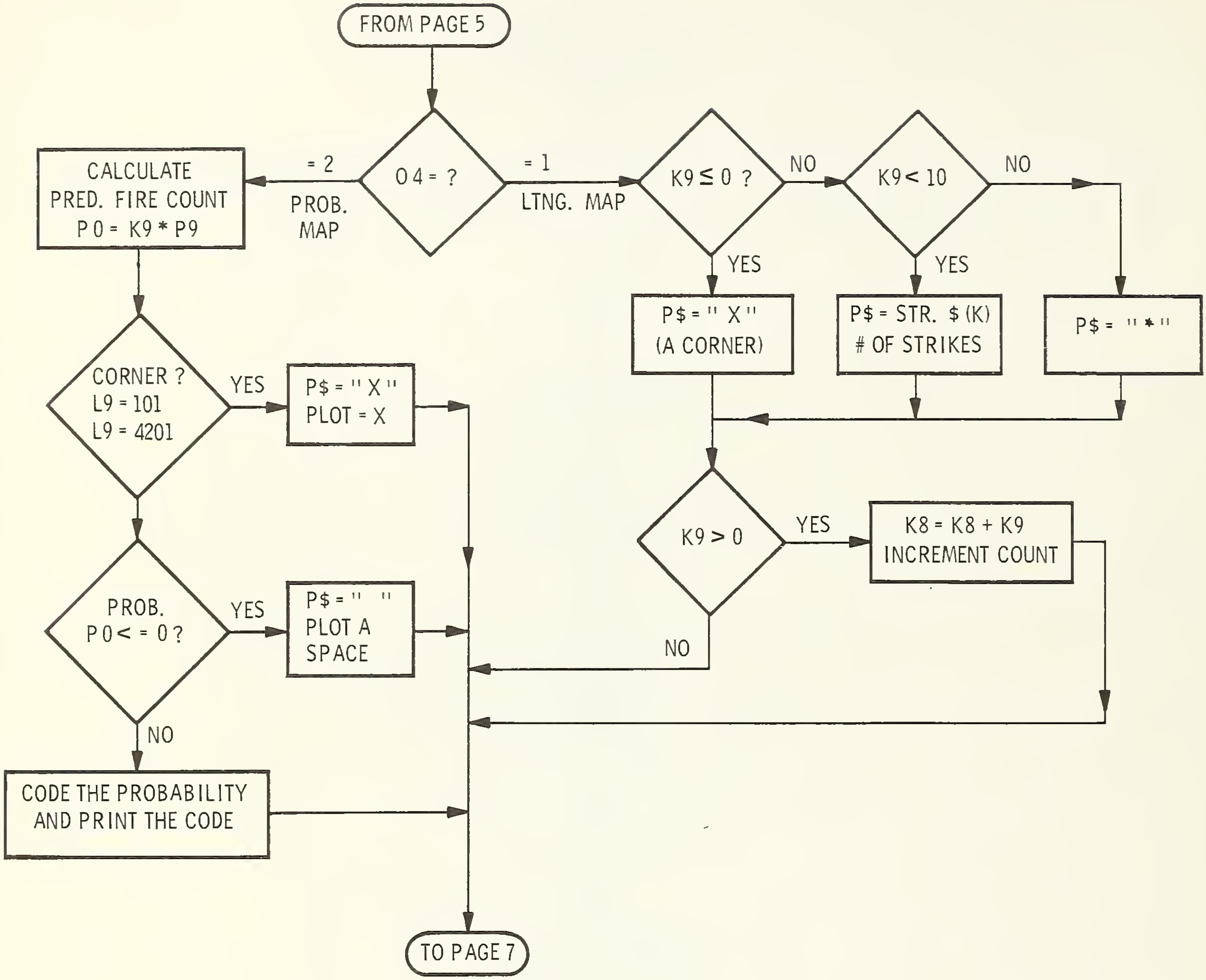
SHOWTIME. BAS
(Page 4)

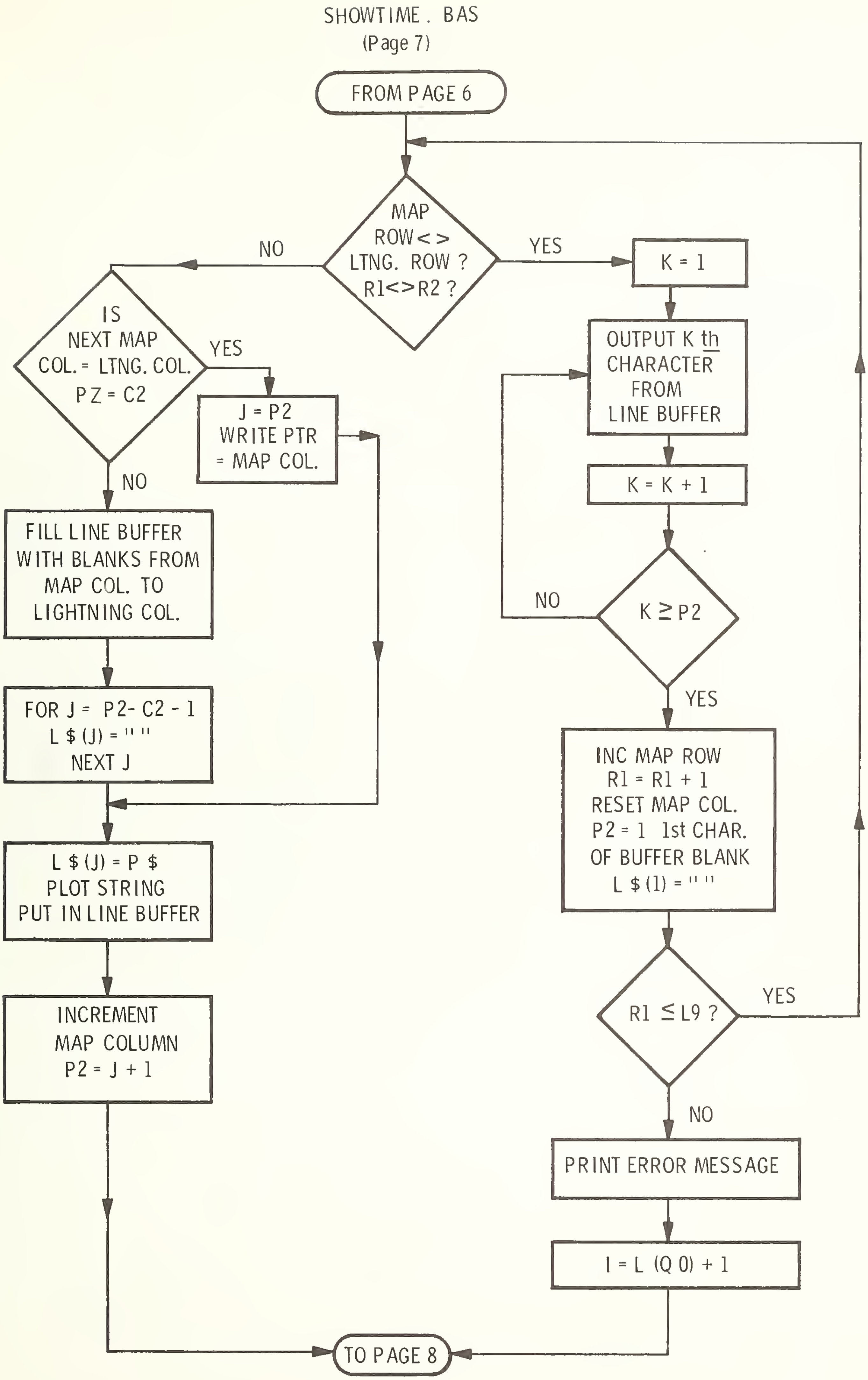


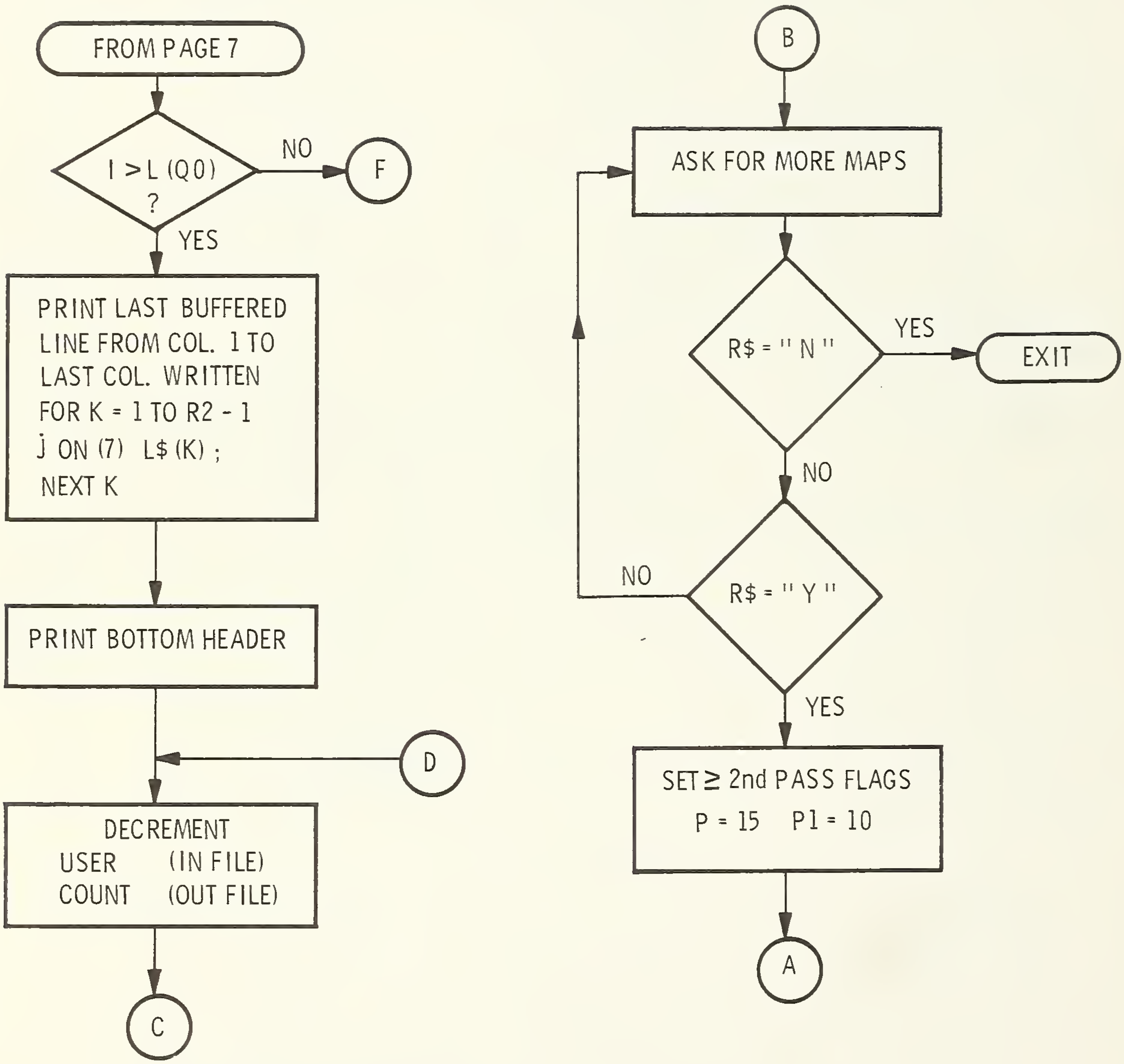
SHOWTIME . BAS
(Page 5)



SHOWTIME. BAS
(Page 6)




SHOWTIME . BAS
(Page 7)
FROM PAGE 6
MAP ROW<> LTNG. ROW ? R1<>R2 ?
NO
YES
K = 1
OUTPUT K th CHARACTER FROM LINE BUFFER
K = K + 1
K ≥ P2
NO
YES
INC MAP ROW R1 = R1 + 1 RESET MAP COL. P2 = 1 1st CHAR. OF BUFFER BLANK L $ (1) = " "
R1 ≤ L9 ?
YES
NO
PRINT ERROR MESSAGE
I = L (Q 0) + 1
IS NEXT MAP COL. = LTNG. COL. PZ = C2
YES
J = P2 WRITE PTR = MAP COL.
NO
FILL LINE BUFFER WITH BLANKS FROM MAP COL. TO LIGHTNING COL.
FOR J = P2- C2 - 1 L $ (J) = " " NEXT J
L $ (J) = P $ PLOT STRING PUT IN LINE BUFFER
INCREMENT MAP COLUMN P2 = J + 1
TO PAGE 8


FROM PAGE 7
I > L (Q0) ?
NO
F
YES
PRINT LAST BUFFERED LINE FROM COL. 1 TO LAST COL. WRITTEN
FOR K = 1 TO R2 - 1
j ON (7) L$ (K) ;
NEXT K
PRINT BOTTOM HEADER
D
DECREMENT
USER (IN FILE)
COUNT (OUT FILE)
C
B
ASK FOR MORE MAPS
R$ = " N "
YES
EXIT
NO
R$ = " Y "
NO
YES
SET ≥ 2nd PASS FLAGS
P = 15 P1 = 10
A

```
##########################################################################

 THIS IS THE SET OF PROGRAMS FOR LLAFFS WRITTEN ON/FOR THE PERKIN-
 ELMER 3200 IN BASIC. THE ABBREVIATION ; IS USED FOR PRINT AT TIMES
 IN THESE PROGRAMS. ALL OTHER FUNCTIONS ARE SPELLED OUT.

##########################################################################
10  REM PROGRAM SQRFIL.BAS -- CREATES AND FILLS THE FILE SQRDATA.DTA
20  REM  THE FILE CAN BE GIVEN A NAME OTHER THAN 'SQRDATA.DTA'
30  DIM F$(12),E$(5)
40  REM **************************************************************
50  REM PROMPT THE USER
60  REM
70  ONERROR GOTO 80
80  PRINT"NUMBER OF SQUARES YOUR AREA IS SECTIONED INTO ?"
90  INPUT S0
100 ONERROR GOTO 110
110 PRINT"NAME FOR THE DATA FILE ?  (TYPE 'D' FOR DEFAULT='SQRDATA.DTA')"
120 INPUT F$
130 IF F$="D" THEN F$="SQRDATA.DTA"
140 REM **************************************************************
150 REM  CREATE  AND OPEN  FILE
160 REM
170 ONERROR GOTO 210
180 CREATE F$,2,4
190 OPEN F$,1,1
200 GOTO 350
210 E$=ERR$(0):E=VAL(E$)
220 IF E=10 THEN ;"ILLEGAL FILE NAME.":GOTO 100
230 IF E<>22 THEN ;"ERR NO."; E ;"AT LINE NO"; ERL(0):STOP
240 PRINT"FILE "; F$ ;" ALREADY EXISTS."
250 PRINT"TO DELETE "; F$ ;"  THEN  RECREATE  IT, TYPE 1"
260 PRINT"TO STOP TYPE 0, TO TRY A NEW NAME. TYPE 2"
270 ONERROR GOTO 240
280 INPUT 01
290 IF 01=0 THEN STOP
300 IF 01=1 THEN DELETE F$:GOTO 170
310 GOTO 100
320 REM *************************************************************
330 REM  FILL THE FILE
340 REM
350 FOR I=1 TO S0
360 ONERROR GOTO 370
370 PRINT"SQUARE NO."; I;"WEATHER STATION NBR.= "
380 INPUT W0
390 ONERROR GOTO 400
400 PRINT"SQR NO."; I ;"FUEL TYPE INDEX.="
410 INPUT F0
420 W0=W0*100+F0
```

```
430 OUTFILE ON(1)W0
440 NEXTI
450 CLOSE1
460 PRINT F$ ;" FILLED AND CLOSED."
470 END
***************************************************************************
  AFFIRMS UPDATING PROGRAM
THIS PROGRAM USES THE FILE AFFIRMS.082 (OR OTHER YEAR)
WHICH MUST BE EXTERNALLY CREATED AT IMPLEMENTATION.
***************************************************************************
10   REM AFFIRMS.BAS -- AFFIRMS.YYY FILE UPDATER
20   CLOSE5:OPEN "CON:",5,0
30   DIM A(73),S0$(1),Y$(4),F$(12)
40   PRINT ON(5)"PROGRAM AFFIRMS//ENTER YEAR OF DATA (2 DIGITS)":INPUT ON(5)Y$
50   F$="AFFIRMS.0"+Y$
60   CLOSE1:OPEN F$,1,0:INFILE ON(1,0)Z,Z1
70   PRINT ON(5)"REWRITE (R)  OR  APPEND(A) ?":INPUT ON(5)S0$
80   IF S0$="R" THEN Z=0 ELSE IF S0$<>"A" GOTO 70
90   IF Z<1 THEN  PRINT ON(5)"WARNING -- IN REWRITE MODE."
100  PRINT ON(5)"ENTER 0 TO STOP , ANY OTHER NUMBER TO CONTINUE."
110  ONERROR GOTO 100
120  INPUT ON(5)S0
130  IF S0=0 THEN STOP
140  PRINT ON(5)"ENTER MO,DAY,HR OF MEAS. (1 OR 2 DIGITS)":INPUT ON(5)M,D,H
150  T=(M-1)*44640+D*1440+H*60
160  ONERROR GOTO 210
170  FOR I=1 TO 73
180  PRINT ON(5)"ENTER STATION NO.  " ; I
190  PRINT ON(5)"LAL=":INPUT ON(5)L
200  PRINT ON(5)"FMI=":INPUT ON(5)F: GOTO 220
210  PRINT ON(5)CHR$(7) ;"ERROR": GOTO 180
220  A(I)=L*100+F
230  NEXTI
240  ONERROR GOTO 370
250  REM (* APPEND NEW DATA TO END OF FILE *)
260  OUTFILE ON(1,Z+1)T,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8)
270  OUTFILE ON(1)A(9),A(10),A(11),A(12),A(13),A(14),A(15),A(16),A(17)
280  OUTFILE ON(1)A(18),A(19),A(20),A(21),A(22),A(23),A(24),A(25),A(26)
290  OUTFILE ON(1)A(27),A(28),A(29),A(30),A(31),A(32),A(33),A(34),A(35)
300  OUTFILE ON(1)A(36),A(37),A(38),A(39),A(40),A(41),A(42),A(43),A(44)
310  OUTFILE ON(1)A(45),A(46),A(47),A(48),A(49),A(50),A(51),A(52),A(53)
320  OUTFILE ON(1)A(54),A(55),A(56),A(57),A(58),A(59),A(60),A(61),A(62)
330  OUTFILE ON(1)A(63),A(64),A(65),A(66),A(67),A(68),A(69),A(70),A(71)
340  OUTFILE ON(1)A(72),A(73)
350  Z=Z+9:OUTFILE ON(1,0)Z,Z1
360  CLOSE1: PRINT ON(5)"DATE " ; T ;" APPENDED TO FILE " ; F$:STOP
370  PRINT ON(5)"ERROR" ; ERR$(165) ;"  LINE" ; ERL(0)
380  END
***************************************************************************
```

UPPER WIND SPEED UPDATE PROGRAM
THIS PROGRAM USES THE FILE UWU.082 (OR OTHER YEAR)
WHICH MUST BE EXTERNALLY CREATED AT IMPLEMENTATION.

```
*************************************************************************
10   REM UWU.BAS -- UPPER WIND SPEED FILE (UWU.YYY) UPDATER
20   CLOSE5:OPEN"CON:",5,0
30   DIM W(4),G(3,3),C(3),S(3)
40   DIM Y$(4),S0$(1),F$(12),C$(12)
50   PRINT ON(5)"PROGRAM UWU"
60   PRINT ON(5)"YEAR PRESENTLY SET FOR 1982":Y$="82"
70   F$="UWU.0"+Y$
80   CLOSE1:OPENF$,1,0:INFILE ON(1,0)Z1
90   PRINT ON(5)"REWRITE (R)  OR  APPEND (A) ? "
100  INPUT  ON(5)S0$
110  IF S0$="R" THEN Z1=0 ELSE IF S0$<>"A" GOTO 90
120  IF Z1<1 THEN PRINT ON(5)"WARNING -- IN REWRITE MODE.": GOTO 150
130  INFILE ON(1,Z1)U,H(1),H(2),H(3)
140  PRINT"LAST UWU RECORD IS " ; U ; H(1) ; H(2) ; H(3)
150  PRINT"ENTER 0 TO STOP, ANY NUMBER TO RESUME UWU-RUN"
160  INPUT  ON(5)I
170  IF I=0 THEN STOP
180  PRINT ON(5)"ENTER 500MB WIND SPD FOR BOISE":INPUT  ON(5)W(1)
190  PRINT ON(5)"ENTER 500MB WIND SPD FOR SPOKANE":INPUT  ON(5)W(2)
200  PRINT ON(5)"ENTER 500MB WIND SPD FOR GRTFALLS":INPUT  ON(5)W(3)
210  PRINT ON(5)"ENTER MO,DAY,HR OF MEAS. (1 OR 2 DIGITS)"
220  INPUT  ON(5)M,D,H
230  T=(M-1)*44640+D*1440+H*60
240  OUTFILE ON(1,Z1+1)T,W(1),W(2),W(3)
250  Z1=Z1+1:OUTFILE ON(1,0)Z1
260  CLOSE1: PRINT ON(5)T;W(1);W(2);W(3);"APPENDED TO ";F$;" FOR ";M;D;H
270  END
*************************************************************************
```

MONITOR PROGRAM
MONITOR USES SEVERAL FILES. THESE ARE SPECIFIC TO
THE APPLICATION, EXCEPT FOR BUFFR1.LTG AND BUFFR2.LTG.
THESE TWO ARE REQUIRED FOR PERIODIC.BAS. ALL FILES IN
MONITOR MUST BE EXTERNALLY CREATED AT IMPLEMENTATION.

```
*************************************************************************
10   CLOSE 7:OPEN "CON:",7,0
20   REM *****  PROGRAM SUPERMON
30   DIM  L$(80),K1$(1),B0$(80),F$(12),Y$(2),M1$(2),D1$(2),X$(1),E$(5)
40   DIM  A9$(1),N9$(1),D2$(1),C1$(1),C2$(1),C3$(1),C4$(1),C5$(1)
50   DIM  B$(10,2),A(73)
60   REM
70   D2$=CHR$(18):C1$=CHR$(1):C2$=CHR$(2):C3$=CHR$(3):C4$=CHR$(4)
80   C5$=CHR$(5):A9$=CHR$(6):N9$=CHR$(21):F=1:U1=1
90   I1=1:I2=2:S1=1
100  B$(1)="BUFFR1.LTG":B$(2)="BUFFR2.LTG"
110  PRINT ON(7)D2$; C2$
```

```
120  ONERROR GOTO 710
130  REM ************************************************************
140  OPEN "HALFHR.CNT",4,0
150  OPEN "VERBOSE.BOI",2,1:OPEN "BUFFR1.LTG",1,1
160   GOTO 250
170  REM *** CHECK FOR  END OF HALF HOUR PERIOD *******************
180  INFILE ON(4,0)S0
190  IF  S0=S1  THEN  RETURN
200  CLOSE U1:F=F+S1:S1=S0
210  OPEN B$(F),U1,1
220  OUTFILE ON(4,1)S1
230  RETURN
240  REM ***** WAIT FOR  INPUT  ON(7) FROM COMPUCORP
250  LINPUT ON(7)B0$
260  X$=B0$(I1,I1):L$=B0$(I2,):T0=ASC(X$)
270  ONT0 GOTO 300,330,470,360
280  PRINT ON(7)D2$; C5$;"PE:INVALID COMMAND": GOTO  250
290  REM...... OUR LTNG INFO HANDLER ......
300  OUTFILE ON(U1)L$
305  GOSUB  180
310  GOTO 250
320  REM...... BOISE LTNG INFO HANDLER ......
330  OUTFILE ON(2)L$
340  GOTO 250
350  REM ...... UPPER WIND HANDLER ......
360  GOSUB 680
370  F$="UWU.0"+Y$:CLOSE 5:OPEN F$,5,0:INFILE ON(5,0)Z,Z1
380  IF Z=Z1 THEN PRINT ON(7)N9$: GOTO 250
390  PRINT ON(7)A9$
400  Z1=Z1+1
410  INFILE ON(5,Z1)A(1),A(2),A(3)
420  FOR I=1TO3:PRINT ON(7)A(I):NEXTI
430  INPUT ON(7)K1$:  IF K1$<>A9$ GOTO 420
440  IF Z=Z1 THEN PRINT ON(7)C3$ ELSE PRINT ON(7)C4$: GOTO 400
450  OUTFILE ON(5,0)Z,Z1:CLOSE 5: GOTO 250
460  REM...... READ LATEST AFFIRMS DATA AND PASS TO COMPUCORP ......
470  GOSUB  680
480  F$="AFFIRMS.0"+Y$:CLOSE 5:OPEN F$,5,0:INFILE ON(5,0)Z,Z1
490  IF Z=Z1 THEN PRINT ON(7)N9$: GOTO 250
500  PRINT ON(7)A9$
510  Z1=Z1+9
520  INFILE ON(5,Z-8)T,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8)
530  INFILE ON(5)A(9),A(10),A(11),A(12),A(13),A(14),A(15),A(16),A(17)
540  INFILE ON(5)A(18),A(19),A(20),A(21),A(22),A(23),A(24),A(25),A(26)
550  INFILE ON(5)A(27),A(28),A(29),A(30),A(31),A(32),A(33),A(34),A(35)
560  INFILE ON(5)A(36),A(37),A(38),A(39),A(40),A(41),A(42),A(43),A(44)
570  INFILE ON(5)A(45),A(46),A(47),A(48),A(49),A(50),A(51),A(52),A(53)
580  INFILE ON(5)A(54),A(55),A(56),A(57),A(58),A(59),A(60),A(61),A(62)
590  INFILE ON(5)A(63),A(64),A(65),A(66),A(67),A(68),A(69),A(70),A(71)
```

```
600  INFILE ON(5)A(72),A(73)
610  PRINT ON(7)T
620  FOR I=1 TO 73:PRINT ON(7)A(I):NEXTI
630  INPUT ON(7)K1$:  IF K1$<>A9$ THEN ;"BAD BLK": GOTO 610
640  IF Z=Z1 THEN PRINT ON(7)C3$ ELSE PRINT ON(7)C4$: GOTO 510
650  OUTFILE ON(5,0)Z,Z1:CLOSE 5
660  GOTO 250
670  REM ...... GET DATE ......
680  D$=GETDATE$(0)
690  Y$=D$(7,8):M1$=D$(1,2):D1$=D$(4,5):RETURN
700  REM...... ERROR HANDLER ......
710  E$=ERR$(0):E=VAL(E$)
720  PRINT ON(7)D2$;C5$;:PRINT ON(7)"ERROR NO -";E*;" AT LINE NO. ";ERL(0)
730  STOP
740  END
******************************************************************************
 PERIODIC......THE FILEMAKER AND PROBABILITY PROGRAM
      PERIODIC USES SEVERAL FILES. ALL MUST BE CREATED AT THE
      TIME OF IMPLEMENTATION. THE FILES ARE: HALFHR.CNT,
      LTOTL.DTA, TEMP.MAP,BUFR.MAP, BUFFR1.LTG, BUFFR2.LTG,
     LTNG.082, AND DAILY.MAP. LTNG.082 IS THE DATA ARCHIVE, AND MAY
     NOT BE NECESSARY FOR SOME USERS.
******************************************************************************
10    REM PROGRAM PERIODIC
20    REM FLOPS THE STATE OF RECORD NBR. 0 IN THE FILE 'HALFHR.CNT'
30    REM EVERY HALF HOUR. MAKES THE MAP 'TEMP.MAP' FOR  SHOWTIME USERS.
40    DIM B$(10,2),K$(2),M1$(2),D$(2),H$(2),M2$(2),L$(80),C9(576)
50    DIM P$(4),T8$(2,4),T9$(2,4),S8$(6),S7$(6),M8$(1),M7$(2)
60    DIM L0(1000),K0(1000),L3(4),M9$(1,2),S8(2),L1$(6),L2$(7)
70    DIM D1$(8),T$(8),D9$(2),N9$(4),F1$(9),F2$(8),L5(4)
80    DIM S(6),S9(6),S3(6),S4(6),A(73),P(576),P9(1000),G(6)
90    REM ****************************************************
100   S(1)=2.856:S(2)=3.372:S(3)=3.896:S(4)=4.944:S(5)=7.04:S(6)=3.896
110   S9(1)=6.856:S9(2)=7.372:S9(3)=7.896:S9(4)=8.944:S9(5)=11.04
120   S3(1)=-86.83:S3(2)=149.21:S3(3)=173.83:S3(4)=201.13:S3(5)=231.29
130   S3(6)=173.83:B=620:C=.7854:Z6=76:S9(6)=7.896
140   A0=170:A9=-1401.65:B9=2822.16:T8=1.44293:Z8=.2
150   S4(1)=2:S4(2)=4:S4(3)=5:S4(4)=6:S4(5)=7:S4(6)=8
160   S1=1:M1=-1:T3=30:F1$="DAILY.MAP":X=117:Y=49:N7=0:N8=0
170   B$(1)="BUFFR1.LTG":B$(2)="BUFFR2.LTG":F2$="BUFR.MAP"
180   L9=47:R9=2:L8=114:R8=3:Z0=0:Y1=24:C6=6
190   S2=1:C1=1:C2=2:C3=3:C4=4:Q0=250:F=2
200   G(1)=0:G(2)=30:G(3)=60:G(4)=130:G(5)=10000
210   FOR I=1 TO 5:G(I)=G(I)*100/250:NEXTI
220   FOR I=1 TO 576:C9(I)=1:NEXTI
230   REM ****************************************************
240   OPEN"HALFHR.CNT",1,0
250   OUTFILE ON(1,0)S1:OUTFILE ON(1,1)S1
260   REM **********************************************
```

```
270   GOSUB 480
280   T9=T0
290   REM ***********************************************
300   FOR I=1 TO 1500:Q=0:NEXTI
310   GOSUB 480
320   IF T0-T9<T3 GOTO 300
330   S1=S1*M1:OUTFILE ON(1,0)S1: GOTO 560
340   REM **********************************************
350   G1=1
360   IF Z<=G(G1) THEN RETURN
370   IF G1=5 THEN RETURN ELSE G1=G1+1
380   GOTO 360
390   REM ************************************************************
400   GOSUB 480
410   T1=T0
420   INFILE ON(X3,0)S
430   IF S=Z0 THEN OUTFILE ON(X3,0)M1:RETURN
440   GOSUB 480
450   IF T0-T1>3 THEN OUTFILE ON(X3.0)M1 ELSE 420
460   RETURN
470   REM ****************************************************
480   D1$=GETDATE$(0):T$=GETTIME$(0)
490   D9$=D1$(1,2):M=VAL(D9$)
500   D9$=D1$(4,5):D=VAL(D9$)
510   D9$=T$(1,2):H=VAL(D9$)
520   D9$=T$(4,5):M2=VAL(D9$)
530   T0=(M-1)*44640+D*1440+H*60+M2
540   RETURN
550   REM *****************************************************
560   L3(1)=2:L3(2)=Q0+2:L3(3)=2*Q0+2:L3(4)=3*Q0+2:P$="0000":F9=0
570   FOR I=0 TO 3:J=Q0*I+1
580   L0(J)=101:L0(J+1)=4201:K0(J)=-1:K0(J+1)=-1:P9(J)=0:P9(J+1)=0
590   NEXTI
600   GOTO 1130
610   REM **********************************************
620   INFILE ON(1,1)S0
630   IF S0<>S2 THEN S2=S0:CLOSE1:RETURN
640   FOR I=1 TO 1500:D1=0:NEXTI
650   GOTO 620
660   REM *********************************
670   OPEN"LTOTL.DTA",2,2
680   INFILE ON(2,0)C8
690   FOR I=1 TO 576:INFILE ON(2)C9(I),Z:NEXTI
700   CLOSE2
710   F=F+S2:OPENB$(F),2,2
720   OPEN"LTNG.082",3,1
730   RETURN
740   REM *********************************
750   INFILE ON(2)L$
```

```
760   IF EOF(2) THEN F9=-1
770   RETURN
780   REM **********************************
790   IF LEN(L$)<>75 THEN RETURN
800   M1$=L$(1,2):D$=L$(3,4)
810   N9$=L$(5,8)
820   IF N9$=P$ THEN RETURN ELSE P$=N9$
830   H$=L$(10,11):M2$=L$(13,14)
840   L1$=L$(26,31):L6=VAL(L1$):L2$=L$(36,42):L7=VAL(L2$)
850   K$=L$(49,50)
860   L1$=L$(54,54):D9=VAL(L1$)
870   S8$=L$(57,62):M8$=L$(65,65):S7$=L$(67,72):M7$=L$(75,75)
880   S8(D9)=VAL(S8$):M9$(D9)=M8$
890   IF D9=C1 THEN D9=C2 ELSE D9=C1
900   S8(D9)=VAL(S7$):M9$(D9)=M7$
910   T9$(1)=M1$:T9$(2)=D$:T9$(3)=H$:T9$(4)=M2$
920   OUTFILE ON(3)L6,L7,S8(1),S8(2),M9$(1),M9$(2),K$,M1$,D$,H$,M2$
930   L1=L9-L6:L2=L8-L7
940   IF ABS(L1)>=R9 THEN RETURN
950   IF ABS(L2)>=R8 THEN RETURN
960   Y2=Y1*INT((Y-L6)*C6)
970   X1=Y2+INT((X-L7)*C4)+1
980   C9(X1)=C9(X1)+1
990   IF L1>=Z0 THEN Z=0 ELSE L1=C2+L1:Z=-2
1000  IF L2>=Z0 THEN Z=Z+C4 ELSE L2=C3+L2:Z=Z+3
1010  C0=INT(L2*24)+C1:R0=INT(L1*21)+C1
1020  B0=R0*100+C0
1030  K=(Q0*(Z-1))+C1
1040  IF (B0<=L0(K))OR(K>L3(Z)) GOTO 1060
1050  K=K+C1: GOTO 1040
1060  IF K>L3(Z) THEN L0(K)=B0:K0(K)=1:P9(K)=P(X1):L3(Z)=K:RETURN
1070  IF B0=L0(K) THEN K0(K)=K0(K)+C1:RETURN
1080  FOR I=L3(Z) TO KSTEP-1
1090  K0(I+1)=K0(I):L0(I+1)=L0(I):P9(I+1)=P9(I):NEXTI
1100  K0(K)=C1:L0(K)=B0:P9(K)=P(X1):L3(Z)=L3(Z)+1
1110  RETURN
1120  REM *****************************************************
1130  GOSUB 620
1140  GOSUB 1980
1150  GOSUB 670
1160  GOSUB 750
1170  IF F9 GOTO 1210
1180  GOSUB 790
1190  GOTO 1160
1200  REM ****************************************
1210  CLOSE2:CLOSE3
1220  OPEN"LTOTL.DTA",2,0
1230  INFILE ON(2,0)C8
1240  FOR I=1 TO 576:INFILE ON(2,I)Z,C8:OUTFILE ON(2,I)C9(I),C8:NEXTI
```

```
1250  CLOSE2
1260  OPEN F1$,2,0:OPEN F2$,3,1
1270  INFILE ON(2,3)L5(1),L5(2):INFILE ON(2,4)L5(3),L5(4)
1280  FOR I=1 TO 4
1290  K=(Q0*(I-1))+1:K1=L5(I)
1300  FOR J=1 TO K1
1310  INFILE ON(2)K4,L4,P4
1320  IF L0(K)<>L4 GOTO 1390
1330  K4=K4+K0(K)
1340  OUTFILE ON(3)K4,L4,P9(K)
1350  K=K+1
1360  IF K<=L3(I) GOTO 1500
1370  IF J=K1 GOTO 1500
1380  J2=J+1: GOTO 1450
1390  IF L0(K)<L4 GOTO 1410
1400  OUTFILE ON(3)K4,L4,P4: GOTO 1500
1410  OUTFILE ON(3)K0(K),L0(K),P9(K)
1420  K=K+1:L5(I)=L5(I)+1
1430  IF K<=L3(I) GOTO 1320
1440  IF J=K1 GOTO 1500 ELSE J2=J
1450  FOR J1=J2 TO K1
1460  INFILE ON(2)K4,L4,P4
1470  OUTFILE ON(3)K4,L4,P4
1480  NEXTJ1
1490  J=J1
1500  NEXTJ
1510  IF K>L3(I) GOTO 1560
1520  FOR J=K TO L3(I)
1530  OUTFILE ON(3)K0(J),L0(J),P9(J)
1540  L5(I)=L5(I)+1
1550  NEXTJ
1560  NEXTI
1570  CLOSE3:OPEN F2$,3,2
1580  X3=2:GOSUB 400
1590  OUTFILE ON(2,2)T9$(1),T9$(2),T9$(3),T9$(4)
1600  OUTFILE ON(2,3)L5(1),L5(2):OUTFILE ON(2,4)L5(3),L5(4)
1610  INFILE ON(3)K4,L4,P4
1620  IF EOF(3) GOTO 1650
1630  OUTFILE ON(2)K4,L4,P4
1640  GOTO 1610
1650  CLOSE3:DELETE F2$:CREATE F2$,2,12
1660  OUTFILE ON(2,0)Z0:CLOSE2
1670  REM ************************************************
1680  OPEN"TEMP.MAP",5,0
1690  X3=5:GOSUB 400
1700  OUTFILE ON(5,1)T8$(1),T8$(2),T8$(3),T8$(4)
1710  OUTFILE ON(5,2)T9$(1),T9$(2),T9$(3),T9$(4)
1720  FOR I=1 TO 4:L3(I)=L3(I)-(Q0*(I-1)):NEXTI
1730  OUTFILE ON(5,3)L3(1),L3(2)
```

```
1740  OUTFILE ON(5,4)L3(3),L3(4)
1750  FOR I=0 TO 3
1760  K=Q0*I
1770  FOR J=K+1 TO K+L3(I+1)
1780  OUTFILE ON(5)K0(J),L0(J),P9(J)
1790  NEXTJ
1800  NEXTI
1810  OUTFILE ON(5,0)Z0
1820  CLOSE5
1830  FOR I=1 TO 4:T8$(I)=T9$(I):NEXTI
1840  DELETE B$(F)
1850  CREATE B$(F),2,78
1860  OPEN"LTOTL.DTA",1,0
1870  INFILE ON(1,0)C8
1880  FOR I=1 TO 576
1890  INFILE ON(1)Z,Z1
1900  GOSUB 350
1910  IF G1<=Z1 THEN 1930
1920  OUTFILE ON(1,I)Z,G1:C8=-1
1930  C9(I)=G1
1940  NEXTI
1950  OUTFILE ON(1,0)C8:CLOSE1
1960  OPEN"HALFHR.CNT",1,0: GOTO 270
1970  REM ***********************************************
1980  N9=-1
1990  OPEN"UWU.082",2,2:INFILE ON(2,0)Z,Z1
2000  IF Z=N7 GOTO 2030
2010  N9=0:N7=Z:INFILE ON(2,N7)Z1,W1,W2,W3
2020  W=(W1+W2+W3)/3
2030  CLOSE2:OPEN"AFFIRMS.082",2,2:INFILE ON(2,0)Z,Z1
2040  IF Z=N8 GOTO 2150
2050  N9=0:N8=Z
2060  INFILE ON(2,Z-8)Z1,A(1),A(2),A(3),A(4),A(5),A(6),A(7),A(8)
2070  INFILE ON(2)A(9),A(10),A(11),A(12),A(13),A(14),A(15),A(16),A(17)
2080  INFILE ON(2)A(18),A(19),A(20),A(21),A(22),A(23),A(24),A(25),A(26)
2090  INFILE ON(2)A(27),A(28),A(29),A(30),A(31),A(32),A(33),A(34),A(35)
2100  INFILE ON(2)A(36),A(37),A(38),A(39),A(40),A(41),A(42),A(43),A(44)
2110  INFILE ON(2)A(45),A(46),A(47),A(48),A(49),A(50),A(51),A(52),A(53)
2120  INFILE ON(2)A(54),A(55),A(56),A(57),A(58),A(59),A(60),A(61),A(62)
2130  INFILE ON(2)A(63),A(64),A(65),A(66),A(67),A(68),A(69),A(70),A(71)
2140  INFILE ON(2)A(72),A(73)
2150  CLOSE2
2160  OPEN"LTOTL.DTA",2,0
2170  INFILE ON(2,0)C8:CLOSE2
2180  IF C8 THEN N9=0
2190  IF N9 THEN RETURN
2200  OPEN"SQRDATA.DTA",2,2
2210  FOR I=1 TO 576
2220  INFILE ON(2)P(I)
```

```
2230  GOSUB 2300
2240  P(I)=P0
2250  NEXTI
2260  CLOSE2
2270  RETURN
2280  REM ****************************************************************
2290  REM FIGURE PROBABILITY FOR  ONE SQUARE
2300  S7=INT(P(I)/100):R1=P(I)-S7*100
2310  R0=S4(R1)*.16E-1
2320  L=INT(A(S7)/100):F0=A(S7)-L*100
2330  IF L<>6 THEN L=C9(I)
2340  D0=-S(L)/W
2350  F5=0:F4=1
2360  IF L=6 GOTO 2420
2370  F5=(S3(L)*W*S(L)+C*S(L)*S(L))/(S3(L)*W*S9(L)+C*S9(L)*S9(L))
2380  F4=1-F5
2390  F3=F0+(Z6-F0)*(1-EXP(D0)):F3=F3/100
2400  E=R0*(A0+B*F3)
2410  P1=(1+(E/B9)^T8)^A9
2420  F3=F0/100
2430  E=R0*(A0+B*F3)
2440  P2=(1+(E/B9)^T8)^A9
2450  P0=(F5*P1+F4*P2)*Z8
2460  RETURN
2470  REM ***********************************************************
2480  END
******************************************************************************
 SHOWTIME ................ FORMATTING AND OUTPUT  PROGRAM
      ALL FILES IN SHOWTIME HAVE ALREADY BEEN CREATED IN IMPLEMENTING
      THE OTHER PROGRAMS.
******************************************************************************
10    REM SHOWTIME
20    CLOSE7:OPEN"CON:",7,0
30    DIM N$(9,4),P$(1),Q$(8),L$(1,73),Q0$(2),N1$(2,4),L1$(73)
40    DIM M$(2),M1$(2),M2$(2),M3$(2),D$(2),D2$(2),H$(2),H2$(2),Q3$(25,2)
50    DIM R$(1),Q9$(39),Q8$(22),Q7$(9,2),O3(3),Q6$(10,2),Q5$(70),Q4$(15,2)
60    N$(1)="NORTHWEST":N$(2)="NORTHEAST"
70    N$(3)="SOUTHWEST":N$(4)="SOUTHEAST"
80    Q9$="WHICH QUADRANT WOULD YOU LIKE  TO  SEE ?"
90    Q8$="ENTER AN OPTION NUMBER"
100   Q7$(1)="TEMP.MAP":Q7$(2)="DAILY.MAP"
110   Q6$(1)="HALF HOUR":Q6$(2)="CUMULATIVE"
120   Q5$="**********************************************************************"
130   Q4$(1)=" LIGHTNING ":Q4$(2)=" EXPECTED FIRE "
140   Q3$(1)=" STRIKES IN THE QUADRANT."
150   Q3$(2)=" SQUARES EXPECTING FIRES."
160   O3(1)=21:O3(2)=43:O3(3)=42
170   N1$(1)="NW":N1$(2)="NE":N1$(3)="SW":N1$(4)="SE":P=38:P1=1:L8=43
180   REM **************************************************************
```

```
190    REM GET USER INPUT
200    ONERROR GOTO  210
210    PRINT ON(7)Q9$(1,P) :"  (NW,NF,SW,SE)"
220    INPUT  ON(7)Q0$
230    REM ************************************************************
240    I=1
250    IF Q0$=N1$(I) THEN Q0=I: GOTO  280
260    I=I+1:IF I>4 GOTO  210 ELSE 250
270    REM ************************************************************
280    IF P=15 THEN 410
290    PRINT ON(7): PRINT ON(7)"   OPTIONS"
300    PRINT ON(7)"      LIGHTNING MAPS"
310    PRINT ON(7)"       1. LAST HALF HOUR"
320    PRINT ON(7)"       2. CUMULATIVE"
330    PRINT ON(7)"      EXPECTED FIRE MAPS"
340    PRINT ON(7)"       3. LAST HALF HOUR"
350    PRINT ON(7)"       4. CUMULATIVE"
360    PRINT ON(7)"      OTHERS"
370    PRINT ON(7)"       5. 1 AND 2"
380    PRINT ON(7)"       6. 3 AND 4"
390    PRINT ON(7)"       7. 2 AND 4"
400    REM ************************************************************
410    ONERROR GOTO  420
420    PRINT ON(7)Q8$(P1)
430    INPUT  ON(7)O2
440    REM ************************************************************
450    IF O2<1 OR O2>7 THEN 420
460    IF O2>4 THEN O2=O3(O2-4)
470    IF O2=0 GOTO  960
480    O4=INT(O2/10):O1=O2-(O4*10):O2=O4:O4=1
490    IF O1>2 THEN O4=2:O1=O1-2
500    REM ***********************************************************
510    ONERROR GOTO  920
520    REM ; REQUESTED MAP
530    CLOSE2:OPEN Q7$(O1),2,0
540    INFILE ON(2,0)S
550    IF S<0 GOTO  540 ELSE OUTFILE ON(2,0)S+1
560    INFILE ON(2)M$,D$,H$,M1$
570    INFILE ON(2)M2$,D2$,H2$,M3$
580    INFILE ON(2)L(1),L(2)
590    INFILE ON(2)L(3),L(4)
600    R9=4
610    IF Q0=1 GOTO  640
620    FOR I=1 TO Q0-1:R9=R9+L(I):NEXTI
630    INFILE ON(2,R9)K9,L9,P9
640    PRINT ON(7): PRINT ON(7)CHR$(12)
650    PRINT ON(7)"THIS IS THE " ; N$(Q0) ;" " ; Q6$(O1) ; Q4$(O4) ;"MAP."
660    PRINT ON(7)"THIS MAP COVERS THE PERIOD"
670    PRINT ON(7)"FROM :  ";M$;"/";D$;"    ";H$;":";M1$;"    (MDT)"
```

```
680   PRINT ON(7)" TO     :  ";M2$;"/";D2$;"     ";H2$;":";M3$;"     (MDT)"
690   IF L(Q0)>2 THEN 710 ELSE PRINT ON(7)
700   PRINT ON(7)"NO LIGHTNING IN THE " ; N$(Q0) ;" MAP AREA.": GOTO 910
710   PRINT ON(7)Q5$
720   PRINT ON(7)
730   REM ****************************************************
740   R1=1:P2=1:K8=0
750   FOR I=1 TO L(Q0)
760   INFILE ON(2)K9,L9,P9
770   R2=INT(L9/100):C2=L9-R2*100
780   ONO4GOSUB 1010,1050
790   IF R1<>R2 THEN 830
800   IF P2=C2 THEN J=P2: GOTO  820
810   FOR J=P2 TO (C2-1):L$(J)=" ":NEXTJ
820   L$(J)=P$:P2=J+1: GOTO  870
830   FOR K=1 TO P2-1: PRINT ON(7)L$(K) ; :NEXTK: PRINT ON(7)
840   R1=R1+1:P2=1:L$(1)=" "
850   IF R1<=L8 GOTO  790
860   PRINT ON(7)"INTERNAL ERROR. UNABLE  TO  FINISH MAP.":I=L(Q0)+1
870   NEXTI
880   FOR K=1 TO P2-1: PRINT ON(7)L$(K) ; :NEXTK: PRINT ON(7)
890   PRINT ON(7)
900   PRINT ON(7)"THERE WERE " ; K8 ; Q3$(O4)
910   PRINT ON(7)Q5$
920   INFILE ON(2,0)S:OUTFILE ON(2,0)S-1:CLOSE2
930   PRINT ON(7): PRINT ON(7)
940   GOTO  470
950   REM *********************************************
960   PRINT ON(7)"MORE MAPS ?  (Y OR N)"
970   INPUT  ON(7)R$
980   IF R$="N" THEN STOP ELSE IF R$="Y" THEN P=15:P1=10: GOTO  200
990   GOTO  960
1000  REM **********************************************
1010  IF K9<=0 THEN P$="X" ELSE IF K9<10 THEN P$=STR$(K9) ELSE P$="*"
1020  IF K9>0 THEN K8=K8+K9
1030  RETURN
1040  REM *****************************************************
1050  P0=K9*P9
1060  IF L9=101ORL9=4201 THEN P$="X":RETURN
1070  IF P0<=0 THEN P$=" ":RETURN
1080  K8=K8+1
1090  IF P0<=.2 THEN P$="1":RETURN
1100  IF P0<=.4 THEN P$="2":RETURN
1110  IF P0<=.8 THEN P$="3" ELSE P$="4"
1120  RETURN
1130  REM ***********************************************
1140  END
```

☆ U.S. GOVERNMENT PRINTING OFFICE: 1983—676-083/1018 REGION NO. 8

Latham, Don. LLAFFS—a lightning-locating and fire-forecasting system. Res. Pap. INT-315. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1983. 44 p.

This paper presents a system for locating lightning strikes and predicting the number of fire ignitions on forests and rangelands. This system uses variables representing weather and fuels and real-time lightning locations as inputs. Outputs from the system consist of printouts designed for use with overlays to map probable fire locations. The programs are designed to be used by field personnel having access to a micro- or minicomputer.

KEYWORDS: lightning, lightning location, ignition probability

The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

The Intermountain Station includes the States of Montana, Idaho, Utah, Nevada, and western Wyoming. About 231 million acres, or 85 percent, of the land area in the Station territory are classified as forest and rangeland. These lands include grasslands, deserts, shrublands, alpine areas, and well-stocked forests. They supply fiber for forest industries; minerals for energy and industrial development; and water for domestic and industrial consumption. They also provide recreation opportunities for millions of visitors each year.

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